TAC H78-001

(NASA-CR-158616) HYDROGEN ENERGY. A BIBLIOGRAPHY WITH ABSTRACTS Quarterly Update, 31 Mar. 1978 (New Mexico Univ.) 62 p

N79-76982

Unclas

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A Bibliography With Abstracts
Quarterly Update March 31, 1978

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HYDROGEN ENERGY

A BIBLIOGRAPHY WITH ABSTRACTS

QUARTERLY UPDATE
JANUARY-MARCH 1978

PREPARED BY THE

ENERGY INFORMATION PROGRAM

of the

TECHNOLOGY APPLICATION CENTER

MAY 1978

THE UNIVERSITY OF NEW MEXICO
ALBUQUERQUE, NEW MEXICO

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PREFACE

HYDROGEN ENERGY is a continuing bibliographic summary with abstracts of research and projections on the subject of hydrogen as a secondary fuel and as an energy carrier. The first volume was published in January, 1974 and is cumulative through December of 1973. Additional copies are available from the Technology Application Center, as are the quarterly update series for 1974, 1975, 1976, and 1977.

This update to HYDROGEN ENERGY cites additional references identified during the first quarter of 1978. It is the first in a 1978 quarterly series intended to provide "current awareness" to those interested in hydrogen energy.

For the reader's convenience, a series of cross indexes are included which track directly with those of the cumulative volume. See "Guide to Use of the Publication."

A library containing some of the articles and publications referenced in this update and the cumulative volume has been established and the Center will, on a cost-recovery basis, aid readers to obtain copies of any cited material. Although a considerable effort has been made to insure that the bibliography is complete, readers are encouraged to bring any omissions to the attention of this Center.

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GUIDE TO USE OF THIS PUBLICATION

A number of features have been incorporated to help the reader use this document. They consist of:

-- A TABLE OF CONTENTS listing general categories of subject content and indexes. More specific coverage by subject title/keyword and author is available through the appropriate index.

-- CITATION NUMBERS assigned to each reference. These numbers, with the prefix omitted, are used instead of page numbers to identify references in the various indexes. They are also used as TAC identifier numbers when dealing with document orders; so please use the entire (prefix included) citation number when corresponding with TAC regarding a reference. An open ended numbering system facilitates easy incorporation of subsequent updates into the organization of the material. In this system, numbers assigned to new citations in each category will follow directly the last assigned numbers in the previous publication. The citation number of the last reference on each page appears on the upper right-hand corner of that page to facilitate quick location of a specific term.

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-- An INDEX OF AUTHORS alphabetized by author's last name. A reference's author is followed by the reference's citation number. For multiple authors, each author is listed in the index.

-- An INDEX OF PERMUTED TITLES/KEYWORDS affords access through major words in the title and through an assigned set of keywords for each citation. A reference's title is followed by the reference's citation number. In the indexes, all the words pertaining to a reference are permuted alphabetically. Thus, the citation number for a reference appears as many times as there are major title words or keywords for that reference. The permuted words run down the center of an index page. The rest of the title or keywords appear adjacent to a permuted word. Since a title or set of keywords is allowed only one line per permuted word the beginning, the end, or both ends of a title or set of keywords may be cut off; or, if space permits, it will be continued at the opposite side of the page until it runs back into itself. A # indicates the end of a title or set of keywords while a / indicates where a title or set of keywords has been cut off within a line.

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I. GENERAL: CONCEPTS, CONFERENCES, SURVEYS, REVIEWS

H78 10001 UNITED STATES TRANSPORTATION FUEL ECONOMICS (1975-1995)

Alexander, A.D., III, (NASA, Moffett Field, CA), Apr 1975, EDB-77:139867, N75-21154
Avail:NTIS

This report describes and evaluates United States transportation fuel economics in terms of fuel resources options, processing alternatives, and attendant economics for the period 1975 to 1995. The U.S. energy resource base is reviewed, portable fuel-processing alternatives are assessed, and selected future aircraft fuel options (JP fuel, liquid methane, and liquid hydrogen) are evaluated economically. The primary emphasis of this study is placed on evaluating future aircraft fuel options and economics to provide guidance for future strategy of NASA in the development of aviation and air transportation research and technology.

(BIOMASS, COST, OIL SHALES)

H78 10002 ROLE OF THE TECHNICAL SERVICE CONTRACTING INDUSTRY IN THE ENERGY PROGRAM

Armstrong, W.C., (Northrop Services, Inc., Anaheim, CA), Western Periodicals Company, North Hollywood, CA, 1976, EDB-77:139759

The technical service contracting industry is comprised of companies, usually attached to and derivative from aerospace and related industry. In testimony before Congress it has been estimated that contracts held by this industry exceed $3.5 billion per year. The purpose of these contracts is to provide scientific, technical, and technically related services, usually to federal agencies. Since the industry's inception, technical service contractors have primarily been supporting the National Aeronautics and Space Administration and the Department of Defense at or near their various facilities. Provided support has included such services as military range operation, computational support, technical and management assistance, and operation of research facilities. More recently, technical support contracts have been awarded to provide support to other agencies such as the Department of Transportation and the Environmental Protection Agency and in the last several years support has been provided to the Energy Research and Development Administration, and to other governmental offices involved in the National Energy Program. Based on projections for necessary technical support, an aggressive energy program to develop and demonstrate alternative energy sources could make extensive use of the Technical Services Industry mandatory. This paper described typical roles that have been or are now being performed by the Industry. These include descriptions of support in the following areas: testing of solar collectors, integration and analytical support of solar heating and cooling programs, development of modular integrated utility systems, evaluation of hydrogen and other advanced energy systems, collection of climatic data, local government energy conservation and resource management programs, energy-related invention analysis, program management/technical administrative services, and potential future support of federally sponsored demonstration projects.

(BUDGETS, DATA COMPILATION, EDUCATION)

H78 10003 RESEARCH AND DEVELOPMENT IN THE INTERNATIONAL ENERGY AGENCY

De Bruine, R.F., Energiespectrum, Netherlands, V 1:39-46, N2, Feb 1977, In Dutch

Formed in 1973, the Agency and its main functions are to investigate coal technology, solar energy, thermonuclear fusion, waste heat utilization, reacitons using process heat, hydrogen production, wind power, geo-thermal energy, ocean thermal gradients and other possible sources of energy. A list is given of the special responsibilities of the various member countries, and of the general co-ordination. A considerable amount of basic research is in progress on all the above subjects.

(ENERGY RESOURCES, MANAGEMENT)

H78 10004 HYDROGEN ECONOMY: A PRELIMINARY TECHNOLOGY ASSESSMENT. EXECUTIVE SUMMARY

Dickson, E.M., Ryan, J.N., Smulyan, M.H., (Stanford Research Institute, Menlo Park, CA), NSF/RA-760743, NSF-EPR73-02706, 15 p., PB-268468/6, N77-85011

No abstract available

(FUELS, PRODUCTION, POLICY)

H78 10005 HYDROGEN ECONOMY STILL A LONG WAY OFF

Gamester, B., Electr. Rev., Great Britain, V 200:16-17, N7, Feb 18, 1977

The author examines the potential of hydrogen as a secondary energy carrier and discusses the technologies available for its mass production.

(SECONDARY ENERGY CARRIER)

H78 10006 TECHNICAL DESIGN AND ECONOMIC VIABILITY OF LARGE-SCALE SOLAR-CELL/ HYDROGEN-FUEL ENERGY SYSTEMS. A RESEARCH PROPOSAL

Greeley, R.S., (Mitre Corp., McLean, VA), 120 p., N77-70488
No abstract available

(MANAGEMENT)

H78 10007 PRESENT STATUS OF RESEARCH AND DEVELOPMENT OF HYDROGEN ENERGY IN THE SUNSHINE PROJECT

Kameda, Y., (Agency Ind. Sci. Technol., Tokyo, Japan), Sekiyu Gakkai Shi, V 19:775-779, N9, 1976, In Japanese
No abstract available

(REVIEW)

H78 10008 HYDROGEN - A POTENTIAL ENERGY CARRIER OF THE FUTURE

Keller, C., (Karlsruhe, Germany), Chem.-Ztg., V 101:223-240, N5, 1977, In German
No abstract available

(REVIEW, ECONOMY)

H78 10009 THE HYDROGEN ECONOMY AND THE CHEMIST

Marchetti, C., (Inst. Appl. Syst. Anal., Schloss Laxenburg, Austria), Chem. Br., V 13:219-222, N6, 1977
No abstract available

(REVIEW, ENERGY)

H78 10010 SYNTHETIC FUELS PROCESSING: COMPARATIVE ECONOMICS

Pelofsky, A.H., ed., (Cities Serv. Res. and Dev. Co., Energy Res. Lab., Cranbury, NJ), Comp Econ for Synfuels Process, Symp., Pap, at Am Chem Soc., Div of Ind and Eng Chem Meet, New York, NY, Apr 4-9, 1976, Publ by Marcel Dekker, Inc., New York, NY, 473 p., 1977

Among others the following subjects are discussed - economic comparison of synthetic fuels, gasification and liquefaction; the relative advantages of coal conversion routes for electric power generation; economics of in-situ coal conversion; flash hydropyrolysis process for conversion of lignite to liquid and gaseous products; the IGT low-BTU gas process-design and economics; fuel gas production via Koppers-Totzek gasification; economics of ethylene production via pyrolysis of coal-based Fischer-Tropsch hydrocarbons; economics of synthetic gas production by the Segas TM process; a comparison of operational economics of transportation vehicles operated on gasoline and coal-generated hydrogen. One paper is concerned with the economics of industrial process heat from solar energy; another one with economics of advanced technology of nuclear electrolyte hydrogen fuel production facility.

(COAL LIQUEFACTION, COAL GASIFICATION)

H78 10011 AN ASSESSMENT OF HYDROGEN AS A MEANS TO STORE SOLAR ENERGY

Ramakumar, R., (Oklahoma State University, Stillwater, OK), In Sharing The Sun: Solar Technology in the Seventies; Proceedings of the Joint Conference, Winnipeg, Canada, Aug 15-20, 1976, International Solar Energy Society, Cape Canaveral, FL, V 8:163-175, 1976, NSF AER-75-00647, (A77-48910 23-44), A77-49107

A brief review and assessment of the use of hydrogen as a means to store solar energy is presented. Electrolytic and non-electrolytic methods proposed for hydrogen production from solar energy, hydrogen storage methods and utilization techniques are surveyed. Overall system concepts with several manifestations of solar energy as inputs are discussed along with their efficiencies and economic aspects.

(COST EFFECTIVENESS, ELECTROLYSIS, TECHNOLOGY)

H78 10012 ENERGY RELATED TECHNOLOGICAL DEVELOPMENT

Walawender, W.P., Fan, L.T., Matthews, J.C., (Chemical Engineering, Kansas State Univ., Manhattan, KS), Apr 26, 1976 - June 30, 1979, Project # KAN00946

This project is directed at development of a continuous pyrolysis pilot plant facility for the recovery of useful products from animal wastes. Produce a synthesis gas (composed primarily of CO, H_2, CO_2 and CH_4) from feedlot manure.

(WASTE-UTILIZATION, MANURES)

H78 10013 HYDROGEN IN THE ENERGY SYSTEM OF THE NETHERLANDS: A POSSIBILITY FOR THE FUTURE

(Nijverheidsorganisatie Tno, Apeldoorn, Netherlands), Sept 1975, NP-21230, EDB-77:137379
Avail:NTIS $3.50, U.S. sales only

The consequences of the shift from fossil to other energy sources to the extent that other resources are dominant were investigated. A scenario is presented on the rate at which, during the transition period, hydrogen can be introduced into the Dutch economy. Production, storage, transmission and distribution, environment and safety, and utilization in stationary units and vehicles are considered. It could be concluded that there are no serious objections in connection with the transition to the use of hydrogen as a fuel.

(SAFETY, TRANSPORT, USES)

H78 10014 RESEARCH ON NONFOSSIL FUEL SOURCES

Gas World Gas J., V 181:526-527, 529-531, N4694, Sept 1976, EDB-77:127636

This article reviews the Chicago Institute of Gas Technology's increasing involvement in the development of nonfossil energy sources: energy from the sun, wind and ocean, and the conversion of waste and plant life to methane and of water to hydrogen. Most work to harness nuclear and solar energy is directed toward the production of electric power. However, IGT has also been studying hydrogen as an alternative fuel form that can be produced from water by the addition of nuclear, solar or other kinds of energy.

(ELECTROLYSIS, OCEAN THERMAL)

H78 10015 HYDROGEN FUEL: A SYSTEM MADE TO MEASURE

VDI, Ver. Dtsch. Ing., Nachr., V 31:6-7, N11, Mar 1977, EDB-77:144543, In German

For the time being, hydrogen is the most attractive alternative fuel for road vehicles. The main problem encountered so far was the storage of hydrogen aboard the vehicle. Here, the use of metal hydrides for storage will open up completely new possibilities. Combined storage (low-temperature and high-temperature storage) and its application are discussed. In this way, it will be possible to achieve a driving range of some 400 KM with a much higher efficiency of the whole system. The cost of hydrogen-powered vehicles is lower than that of electric-powered vehicles. The article closes with a survey of research programs on the introduction of hydrogen-powered vehicles in road traffic.

(COST, EFFICIENCY, FORECASTING)

H78 10016 RESEARCH AND EXPLORATORY DEVELOPMENT. QUARTERLY REPORT

(Applied Physics Lab., Johns Hopkins Univ., Silver Spring, MD), NASA-CR-154966, 14 p., N77-85453
Avail:NTIS

No abstract available

(FUEL COMBUSTION, HYDROGEN)

H78 10017 ENERGY DEVELOPMENT III

(Institute of Electrical and Electronics Engineers, Inc., New York), 176 p., 1977, For individual items see A78-11070 to A78-11088, A78-11069

Attention is given to the operation of MHD/steam systems, coal-based options for the generation of electricity, wind generator economics in a load duration context, solid waste utilization for electric power generation, and the storage of off-peak thermal energy in oil. Consideration is also given to hydrogen cycle peak shaving on the New York State grid using fuel cells, the battery energy storage test facility, air storage system energy transfer (asset) plants, solar energy and domestic heating needs in France, power generation in Canada, and the energy plantation as an energy alternative fuel-source.

(CONTROLLED FUSION, SOLID WASTES)

II. PRODUCTION

H78 20001 TRENDS IN ELECTROCHEMISTRY

Bockris, J.O'M., ed., Rand, D.A.J., ed., Welch, B.J., ed., (Flinders Univ. of South Australia, Bedford Park, Australia), Trends in Electrochem: Australian Electrochem Conf, 4th, Flinders Univ. of South Australia, Bedford Park, Feb 16-20, 1976, Publ by Plenum Press, New York, NY, 408 p., 1977

Contained within this volume are twenty-three plenary lectures and invited papers that outline those aspects of electrochemistry which may underlie the future energy technology. Topics dealing directly with energy developments include: fuel cell applications; solar energy; hydrogen production; and sodium-sulfur batteries. A section covering mineral sulfide electrochemistry is included as well as a section on advances in electrochemical techniques.

(BATTERIES, HYDROGEN FUELS)

H78 20002 ELECTROCHEMISTRY AND THE HYDROGEN ECONOMY

Gregory, D.P., (Inst. of Gas Technology, Chicago, IL), Mod. Aspects Electrochem., V 10:239-288, 27 refs, 1975, EDB-77:131012

The author explores the present status of the hydrogen-economy concept to acquaint the electrochemist not only with the direct implications of such a system to his field, but also with the broader issues involved which could have far-reaching ramifications for the entire energy-conversion field. This work, deals with the whole broad concept of using hydrogen as a universal fuel, with emphasis placed on those areas in which electrochemical science and technology are directly relevant.

(GLOBAL ASPECTS, TECHNOLOGY ASSESSMENT)

H78 20003 EXTENDED ABSTRACTS OF THE BIENNIAL AIR FORCE ELECTROCHEMISTRY CONFERENCE

Hussey, C.L., King, L.A., (Air Force Academy, CO), Conf. held in Colorado, 59 p., Apr 28-29, 1977, N78-70381
Avail:NTIS

No abstract available

(ELECTRIC BATTERIES, CADMIUM BATTERIES)

H78 20004 ELECTROCHEMICAL ENGINEERING

Nanis, L., Bockris, J.O., Javet, P., (Pennsylvania Univ., Philadelphia, PA), Dec 1976, EDB-77:146041, N68-21038
Avail:NTIS

No abstract available

(MATHEMATICAL MODELS, RESEARCH PROGRAMS)

H78 20005 ON BOARD ELECTROLYTIC GENERATOR FOR BREATHABLE OXYGEN AND HYDROGEN UNDER 50 BARS

Perroud, P., Sylvestre-Baron, M., Terrier, G., (Commissariat A L'Energie Atomique, Grenoble, France), Presented at the Coll. Intern. sur L'Exploit. des Oceans, Bordeaux, France, 9 p., October 1-4, 1974, N77-72801, In French, English summary
Avail:NTIS

No abstract available

(DIAPHRAGMS -MECHANICS, SUBMARINES)

H78 20501 COMMERCIAL APPLICATIONS OF INERTIAL CONFINEMENT FUSION

Booth, L.A., Frank, T.G., (Los Alamos Scientific Lab., Los Alamos, NM), NTIS 64-(ISS02)78, 35 p., May 1977, (Contract: W-7405-ENG-36)
Avail:ERDA, P.O. Box 62, Oak Ridge, TN

Described in this report are the fundamentals of inertial-confinement fusion, some laser-fusion reactor (LFR) concepts, and attendant means of utilizing the thermonuclear energy for commercial electric power generation. In addition, other commercial energy-related applications, such as the production of fissionable fuels, of synthetic hydro-carbon-based fuels, and of process heat for a variety of uses, as well as the environmental and safety aspects of fusion energy, are discussed. Finally, the requirements for commercialization of laser fusion technologies are described.

(HYBRID REACTORS, REVIEWS, SAFETY)

H78 20502 ASSESSMENT OF VERY HIGH-TEMPERATURE REACTORS IN PROCESS APPLICATIONS

Jones, J.E., Gambill, W.R., Cooper, R.H., Fox, E.C., Fuller, L.C., (Oak Ridge National Lab., TN), p. 114, June 1977, (Contract No. W-7405-ENG-26)

Presented is a critical review of the technology and economics for coupling a very high-temperature gas-cooled reactor to a variety of process applications. It is concluded that nuclear steam reforming of light hydrocarbons for coal conversion could be a near-term alternative and that direct nuclear coal gasification could be a future consideration. Thermochemical water splitting appears to be more costly and its availability farther in the future than the coal-conversion systems. Nuclear steelmaking is competitive with the direct reduction of iron ore from conventional coal-conversion processes but not competitive with the reforming of natural gas at present gas prices. Nuclear process heat for petroleum refining, even with the necessary backup systems, is competitive with fossil energy sources. The processing with nuclear heat of oil shale and tar sands is of marginal economic importance.

(COAL GASIFICATION, COMMERCIAL ENERGY)

H78 21001 CHEMICAL REACTION CYCLES FOR THE RECOVERY OF LOW-LEVEL THERMAL ENERGY

Fujii, Shigetaka, Kameyama, Hideo, Yoshida, Kunio, Kunii, Daizo, (Dep. Chem. Eng., Univ. Tokyo, Tokyo, Japan), J. Chem. Eng. Japan, V 10:224-228, N3, 1977

No abstract available

(HEAT PUMP, THERMODYNAMICS)

H78 21002 CHEMICAL AND PROCESS DESIGN STUDIES OF THERMOCHEMICAL CYCLES FOR HYDROGEN PRODUCTION

Krikorian, O.H., Pearson, R.K., Otsuki, H.H., Elson, R.E., (California Univ., Livermore, Lawrence Livermore Lab, CA), 17 p., Apr 13, 1977, (Contract No. W-7405-ENG-48)

A modification of the ZnSe thermochemical cycle has been made recently to convert $ZnCl_2$ directly to ZnO and reduce the amount of $ZnSO_4$ that needs to be decomposed at high temperatures. The modified cycle shows significant advantages in efficiency and process design. Exploratory research on the reaction, $ZnCl_2$ (l) + H_2O (g) implies ZnO(s) + 2HCL (g), showed the reaction rate to be quite rapid; i.e., 53 percent of equilibrium being attained in 2s at $800^{\circ}K$. Detailed research has also been conducted at the kinetics and mechanism of decomposition of H_2Se. A process design and economic analysis of the modified cycle indicates the following: overall thermal efficiency is approximately 42 percent, and hydrogen production cost is approximately \$13.22/10^6 KJ in 1976 dollars for a plant producing 27,000 KG H_2/h. In the CH_4 -CH_3OH cycle, attempts thus far to convert CH_3OH to CH_4 by reaction with metal oxides and SO_2 have led to unacceptably high amounts of H_2O, CO_2 and organic compounds as by-products. In future studies on this cycle, the lower oxides of As, Sb, and V will be explored as reducing agents for CH_3OH.

(COST, EFFICIENCY, ZINC OXIDES)

H78 21003 CONVERSION OF AMMONIA INTO HYDROGEN AND NITROGEN BY REACTION WITH A SULFIDED CATALYST

Matthews, C.W., Journal United States, 4 p., Assignee, ERDA, Patent No. 4032618

No abstract available

(WASTEWATER TREATMENT)

H78 21004 RECENT DEVELOPMENTS IN THE ENGINEERING AND CHEMISTRY OF THE ZnSe THERMOCHEMICAL HYDROGEN CYCLE

Otsuki, H.H., Pearson, R.K., Krikorian, O.H., (California Univ., Lawrence Livermore Lab, Livermore, CA), NTIS 64-(ISS02)78 v, 9 p., May 19, 1977, (Contract No. W-7405-ENG-48), (Report No. CONF-770804-5), Intersociety Energy Conversion Engineering Conference, Washington, DC, Aug 28, 1977

Improvements of the ZnSe thermochemical cycle for hydrogen production are described. The authors also present recent findings on the $ZnCl_2$ high temperature steam hydrolysis of liquid $ZnCl_2$ and on the kinetics of decomposition of H_2Se. A preliminary design of a process based on the improved cycle was prepared to examine its overall thermal efficiency and to derive hydrogen production costs. Conceptual designs for several critical equipment items are shown and their special features discussed. Overall thermal efficiency of the cycle depends strongly on our ability to recover reaction heats and match them with process heat requirements. Thermal efficiency of the cycle is estimated to be about 42 percent and estimated cost for hydrogen production is about $13/GJ.

(COST, EFFICIENCY, PRODUCTION)

H78 21005 METHOD FOR THE PRODUCTION OF HYDROGEN BY WATER SPLITTING

Schulten, R., Barnert, H., German, FRG, Patent 2,365,120,A, July 10, 1975, EDB-77:127068, In German

In the first process step of a thermochemical cycle process, steam and sulphur dioxide are reacted as a gas mixture in a certain volume ratio with an oxide of one of the metals manganese, iron, cobalt, nickel, zinc or cadmium to form a metal sulphate and to release hydrogen in the temperature region of 200 to 400°C. The hydrogen is separated off according to known methods. In a second process step, the metal sulphate is heated up to a temperature region of 700-1,000°C for decompoisiton and formation of metal oxide, sulphur dioxide and oxygen. The oxygen gas is separated from the sulphur dioxide gas using known methods. The claims deal with the steam-sulphur dioxide volume ratio (preferably 5:2), the temperature regions depending on the sort of metal, as well as with the nature of the metal oxide and its carrier.

(CHEMICAL REACTIONS, THERMOCHEMICAL PROCESSES)

H78 21501 HYDROGEN PRODUCTION BY THERMOCHEMICAL REACTIONS

Hofmann, H., (Univ. of Erlangen-Nuernberg, Erlangen, Germany), Int. Chem. Eng., V 17:409-413, N3, 16 refs, July 1977

One energy alternative is the use of hydrogen generated by thermal splitting of water by available nuclear or solar energy. In order that this splitting may be carried out at temperatures below 1000°C a number of cyclic processes have been proposed based on the ease with which metal halides, for example, change valence. The chemistry, thermodynamics, and kinetics of the most developed of these thermochemical cycles are reviewed and the difficulties in their technical realization are pointed out.

(SOLAR ENERGY, KINETICS, CYCLES)

H78 22001 ALLOY CATALYSTS WITH MONOLITH SUPPORTS FOR METHANATION OF COAL-DERIVED GASES: PHASE TWO. QUARTERLY TECHNICAL PROGRESS REPORT, OCTOBER 23, 1976 - JANUARY 22, 1977

Bartholomew, C.H., (Brigham Young Univ., Provo, UT), 65 p., Feb 6, 1977, (Contract No. EX-76-C-01-1790)

Presented are the accomplishments during the seventh quarter of investigation of new pellet- and monolithic-supported alloy catalysts for methanation of coal synthesis gas. Monolithic-supported nickel and nickel-cobalt catalysts were prepared. Hydrogen adsorption uptakes were measured for several pelleted and monolithic nickel and nickel alloy catalysts. Differential activity tests were conducted at 225 and 250°C, 20.5 psia, and 30,000 hr^{-1} for nickel-cobalt and nickel-platinum catalysts before and after exposure to 10 PPM H_2S. Thermodynamic calculations were performed to determine conditions for formation of carbon, ammonia, and carbon dioxide in reactor tests. Effects of 1 percent water on methanation activity and selectivity were determined for nickel and nickel alloy catalysts.

(SYNTHESIS GAS, CATALYTIC EFFECTS)

H78 22002 RESEARCH AND DEVELOPMENT OF RAPID HYDROGENATION FOR COAL CONVERSION TO SYNTHETIC MOTOR FUELS (RISER CRACKING OF COAL). QUARTER REPORT, APRIL 1 - JUNE 30, 1976

Duncan, D.A., Beeson, J.L., Oberle, R.D., (Institute of Gas Technology, Chicago, IL), 30 p., N77-77919

Avail:NTIS

No abstract available

(LIQUEFACTION, ENERGY POLICY)

H78 22003 AGGLOMERATION AS A FACTOR IN THE DESIGN OF LOW BTU-GASIFICATION SYSTEMS

Galli, A.F., (West Virginia Geological and Economic Survey, Morgantown, WVA), Proceedings of the Coal Agglomeration and Conversion Symposium, Smith, C.J., comp., Apr 1976, EDB-77:123406

The agglomerating properties of some coals require added steps or more complex processing in their conversion to low BTU gas. Since all processes for the conversion of coal to low BTU gas operate at temperature above the coal agglomeration temperature range, the coal must at some stage during its processing pass through the agglomerating phase to cause operating problems and therefore, special techniques must be used in order to minimize its deleterious effect on the process. The agglomerating properties must be removed with minimum effect on the operation of the process. The methods of destroying the agglomerating properties of caking coal are: pyrolysis, oxidation, and hydrogen treatment.

(CHEMICAL REACTIONS, COAL GASIFICATION)

H78 22004 CURRENT DEVELOPMENTS IN OIL SHALE RESEARCH AT THE LARAMIE ENERGY RESEARCH CENTER

Jacobson, I.A., Jr., Burwell, E.L., Harak, A.E., Long, A., Wise, R.L., (U.S. ERDA, Laramie, WY), Monogr on Alternate Fuel Resour. Based on Pap. Presented at the Symp. on Alternate Fuel Resour, Santa Maria, CA, Mar 25-27, 1976, Publ by West Period Co., North Hollywood, CA, AIAA, V 20:211-225, 5 refs, 1976

Research being conducted at the Laramie Energy Research Center on oil shale is many faceted, and some of the recent developments in these areas are presented. Concurrent gasification and retorting of oil shale where the effects of operating pressure and amounts of oxygen and water injection on quality and quantity of gas and oil produced is being studied. This work has resulted in off gas with heating values varying from 50 to 1,300 BTU/FT^3 and oil recovery of up to 80 vol percent of Fischer assay. The effects of retorting atmosphere, pressure, and external heating rate are being studied in a high pressure batch retort. Results from this work indicate that a nitrogen atmosphere decreases oil yield slightly while a hydrogen atmosphere increases the oil yield significantly.

(LIQUID FUELS, MANUFACTURE)

H78 22005 PHASE EQUILIBRIA IN COAL HYDROGENATION SYSTEMS. QUARTERLY REPORT, OCTOBER - DECEMBER 1976

Kobayashi, R., (Rice Univ., Houston, TX), 10 p., 1976, (Contract No. EX-76-S-01-2334).

One of the objectives of this program is to investigate the thermodynamic properties of chemical mixtures in coal hydrogenation systems and to provide fundamental information for process development and equipment design in coal liquefaction plants. Specifically, the proposed research is to measure vapor-liquid equilibria including K values, dew point and hydrogen solubility in chemical components and their mixtures. The phase equilibria studies and determination of K-values will be made using a gas-liquid perturbation chromatography technique. Preparation of ultra-high purity materials for these equilibria studies will be accomplished with new zone refining apparatus to be developed. Purity will be established by freezing point depression determination. High purity materials are needed for the K-value and solubility studies because of the extreme sensitivity of physiochemical properties to composition. H_2 solubility in coal components and mixtures will be measured via specially designed apparatus combining an equilibrium cell with a high precision transfer pump.

(GAS CHROMATOGRAPHY, MIXTURES)

H78 22006 SUBSTITUTION ENERGETICS FOR HYDROCARBONS

Lartigue, G.J., (Fac. Quim., Univ. Nac. Auton, Mexico, Mexico City, Mexico), Rev. Soc. Quim. Mex., V 21:56-59, N2, 1977, In Spanish

No abstract available

(ELEC ENERGY UTILIZATION)

H78 22007 THE FUTURE PRODUCTION OF LIQUID AND GASEOUS HYDROCARBONS THROUGH COAL GASIFICATION AND THE LONG-TERM PROSPECTS OF A HYDROGEN TECHNOLOGY

Peters, W., Schulten, R., Speich, P., (Steinkohlenbergbauverein, Essen, West Germany), Brennstoff-Waerme-Kraft, V 29:371-376, Sept 1977, A77-51156, In German

No abstract available

(GERMANY, METHANE)

H78 22008 HYDRODENITROGENATION OF COAL DERIVED LIQUID. PhD THESIS

Satchell, D.P., Jr., (Oklahoma State Univ., Stillwater, OK), 203 p., N77-78579
Avail:Univ. Microfilms, Order No. 77-5222
No abstract available

(CATALYTIC ACTIVITY, ENERGY TECHNOLOGY)

H78 22009 NEW POSSIBILITIES FOR UNDERGROUND GASIFICATION BY THE PRESSURE CHANGE PROCESS AND BY INJECTION OF HEAT FROM NUCLEAR REACTORS

Wenzel, W., Franke, F.H., Meraikib, M., (McElroy, Ralph, Company, Austin, TX), Glueckauf-Forschungsh, West Germany, V 33, 18 p., N4, Aug 1-6, 1972, N77-70137, In German, English translation
No abstract available

(EXOTHERMIC REACTIONS, METHANE)

H78 22010 THE CATALYZED HYDROGEN AND STEAM GASIFICATION OF COAL AND COAL CHARS. PhD THESIS

Wilks, K.A., (Case Western Reserve Univ., Cleveland, OH), p. 253, N77-84364
Avail:Univ. Microfilms, Order No. 77-11941
No abstract available

(STEAM, REACTION KINECTICS)

H78 22011 NUMERICAL MODEL OF COAL GASIFICATION IN A PACKED BED

Winslow, A.M., (California Univ., Livermore, CA), Presented at 16th Intern. Symp. on Combustion, Cambridge, MA, 26 p., Aug 15, 1976
Avail:NTIS
No abstract available

(PROCESS ENGINEERING)

H78 22012 PREPARATION OF A COAL CONVERSION SYSTEMS TECHNICAL DATA BOOK. PROJECT 8979 QUARTERLY REPORT, NOVEMBER 1, 1976 - JANUARY 31, 1977

(Institute of Gas Technology, Chicago, IL), 196 p., Apr 1977, (Contract No. EX-76-C-01-2286)
The experimental data from benzene-water systems in a graphical form are presented. Additional Russian data on dissociation of hydrogen sulfide and solubility of carbon dioxide in water at elevated temperatures and pressures were considered in the development of vapor-liquid equilibria for the $NH_3CO_2H_2SH_2O$ system. Available data on partial pressures of ammonia in the $NH_3H_2SH_2O$ system are used to estimate the effect of the ionic ammonium hydrosulfide on the solubility of ammonia. Comparative properties are presented for coals produced by conventional and continuous mining. Occurrence of trace elements in coal is tabulated. Various properties of coal liquids are given along with data on the upgrading of coal liquids for use as power generation fuels. Sulfur reduction in coals from different regions accomplished by washing is given.

(CHEMICAL ANALYSIS, FLUIDIZED-BED COMBUSTION)

H78 22013 OPTIMIZATION STUDIES OF VARIOUS COAL-CONVERSION SYSTEMS. QUARTERLY REPORT, JULY - SEPTEMBER 1976

(West Virginia Univ., Morgantown, WVA), 32 p., N77-83356
Avail:NTIS
No abstract available

(OPTIMIZATION, HYDRODYNAMICS, INDUSTRIAL PLANTS)

H78 23001 POTENTIAL FUEL PRODUCTION FROM MAGMA

Northrup, C.J.M., Jr., Gerlach, T.M., Modreski, P.J., Galt, J.K., (Sandia Labs., Albuquerque, NM), June 1977, SAND-77-0509, EDB-77:137670
Avail:NTIS
Recent calculations and measurements indicate that basaltic magma is a new, extensive source for fuels (hydrogen, carbon monoxide, and methane). The fuel production

processes have been found to occur in nature as well as the laboratory and as a result, the work indicates that current concepts of geothermal energy can be broadened beyond producing only steam and heat. When magma is considered as a geothermal resource, its use for the direct production of fuels should be included. It is possible to generate several mole percent hydrogen when water-rich fluid is equilibrated with the ferrous and ferric iron in magma. The basis of the fuel production processes, the fuel yields for injected water and water plus natural organic matter, and the increased geothermal resources that would be made available by these processes are described.

(NATURAL OCCURRENCE, ROCK-FLUID INTERACTIONS)

H78 23002 HYDROGEN QUANTUM YIELDS IN THE 360 NM PHOTOLYSIS OF EU/2+ SOLUTIONS AND THEIR RELATIONSHIP TO PHOTOCHEMICAL FUEL FORMATION

Ryason, P.R., (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA), Solar Energy, V 19:445-448, NS, 1977, A77-50203

Water decomposition by a cyclic photoredox process is discussed in general terms. Thermodynamics determines the wavelength of the charge-transfer band corresponding to electron transfer to or from water of hydration of a cation. These relationships indicate that it is unlikely that a photoreduction reaction resulting in water decomposition will occur in the sea-level solar range of wavelengths. Such is not the case for photooxidation, and an example is known - the photolysis of EU(2+) in aqueous solution. Hydrogen quantum yields have been determined for this reaction. They are sufficiently high (about 0.3) as to offer encouragement for the further exploration of photoredox reactions as a means of solar energy conversion.

(ENERGY CONVERSION EFFICIENCY, SUNLIGHT)

H78 23003 AMMONIUM HYDROGEN SULFATE DECOMPOSITION FOR STORAGE OF ENERGY FOR ELECTRICAL POWER GENERATION

Wentworth, W.E., Chen, E., (Univ. of Houston, TX), Sharing the Sun: Solar Technology in the Seventies, Joint Conference of the International Solar Energy Society, American Section and Solar Energy Society of Canada, Inc., Winnipeg, Manitoba, Canada, Aug 15-20, 1976, Publ by Int Sol Energy Soc., Am Sect, Cape Canaveral, FL, V 8:226, 1976

Discussion is centered on the decomposition of ammonium hydrogen sulfate (NH_4HSO_4) into NH_3, H_2O, and SO_3 as a storage of energy which can be used subsequently for power generation (450-500°C). The change in enthalpy, ΔH, is extremely high = 80 KCAL/MOLE. This high heat content combined with the fact that the products can be stored as liquids leads to a high capacity for energy storage, = 740 KCAL/LITER. This reaction occurs without a catalyst and the product SO_3 must be stored separately from NH_3 and H_2O. The details of the separation are discussed along with the thermodynamics and kinetics of the reactions involved.

(CHEMICAL REACTIONS, REACTION KINETICS)

H78 23401 COMBINATION OF A HIGH-TEMPERATURE REACTOR WITH A PLANT FOR SPLITTING OFF AND SEPARATION OF HYDROGEN AND WITH A THERMAL POWER PLANT

Bachl, H., German, FRG, Patent 2,507,821,A, Sept 2, 1976, EDB-77:139338, In German

The combination of a high temperature nuclear reactor with a plant for the production of hydrogen from the working steam of a steam power process is suggested in which the working steam is heated up at low pressure using the high temperature of the helium circuit and the hydrogen is thus split off and separated. The working steam is then cooled down and the remaining heat is used for a tertiary process or recycled into the primary process.

(PROCESS HEAT REACTORS, PYROLYSIS)

H78 23402 MULTISTAGE THERMAL DECOMPOSITION PROCESS AND RADIATION DECOMPOSITION PROCESS OF WATER

(ISU, Tokyo, Japan), Latest Literature on Hydrogen Technology, 1975, EDB-77:144531, In Japanese

The principle and development of the processes for producing hydrogen from water by using nuclear fission energy, particularly those of the multistage decomposition process using nuclear heat and the radiation decomposition process using radiation energy, are described. This report is divided into five parts, namely: (1) the principle of thermochemical decomposition of water, (2) the thermodynamical functions for the substances related to the multistage thermochemical decomposition process, (3) the constitution of the multistage thermochemical decomposition process, (4) the reaction cycle and thermodynamical study of the multistage thermochemical decomposition processes have been found to occur in nature as well as the laboratory and as a result, the work indicates that current concepts of geothermal energy can be broadened beyond producing only steam and heat. When magma is considered as a geothermal resource, its use for the direct production of fuels should be included. It is possible to generate several mole percent hydrogen when water-rich fluid is equilibrated with the ferrous and ferric iron in magma. The basis of the fuel production processes, the fuel yields for injected water and water plus natural organic matter, and the increased geothermal resources that would be made available by these processes are described.

(NATURAL OCCURRENCE, ROCK-FLUID INTERACTIONS)

H78 23002 HYDROGEN QUANTUM YIELDS IN THE 360 NM PHOTOLYSIS OF EU/2+ SOLUTIONS AND THEIR RELATIONSHIP TO PHOTOCHEMICAL FUEL FORMATION

Ryason, P.R., (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA), Solar Energy, V 19:445-448, NS, 1977, A77-50203

Water decomposition by a cyclic photoredox process is discussed in general terms. Thermodynamics determines the wavelength of the charge-transfer band corresponding to electron transfer to or from water of hydration of a cation. These relationships indicate that it is unlikely that a photoreduction reaction resulting in water decomposition will occur in the sea-level solar range of wavelengths. Such is not the case for photooxidation, and an example is known - the photolysis of EU(2+) in aqueous solution. Hydrogen quantum yields have been determined for this reaction. They are sufficiently high (about 0.3) as to offer encouragement for the further exploration of photoredox reactions as a means of solar energy conversion.

(ENERGY CONVERSION EFFICIENCY, SUNLIGHT)

H78 23003 AMMONIUM HYDROGEN SULFATE DECOMPOSITION FOR STORAGE OF ENERGY FOR ELECTRICAL POWER GENERATION

Wentworth, W.E., Chen, E., (Univ. of Houston, TX), Sharing the Sun: Solar Technology in the Seventies, Joint Conference of the International Solar Energy Society, American Section and Solar Energy Society of Canada, Inc., Winnipeg, Manitoba, Canada, Aug 15-20, 1976, Publ by Int Sol Energy Soc., Am Sect, Cape Canaveral, FL, V 8:226, 1976

Discussion is centered on the decomposition of ammonium hydrogen sulfate (NH_4HSO_4) into NH_3, H_2O, and SO_3 as a storage of energy which can be used subsequently for power generation (450-500°C). The change in enthalpy, ΔH, is extremely high ≈ 80 KCAL/MOLE. This high heat content combined with the fact that the products can be stored as liquids leads to a high capacity for energy storage, ≈ 740 KCAL/LITER. This reaction occurs without a catalyst and the product SO_3 must be stored separately from NH_3 and H_2O. The details of the separation are discussed along with the thermodynamics and kinetics of the reactions involved.

(CHEMICAL REACTIONS, REACTION KINETICS)

H78 23401 COMBINATION OF A HIGH-TEMPERATURE REACTOR WITH A PLANT FOR SPLITTING OFF AND SEPARATION OF HYDROGEN AND WITH A THERMAL POWER PLANT

Bachl, H., German, FRG, Patent 2,507,321,A, Sept 2, 1976, EDB-77:139338, In German

The combination of a high temperature nuclear reactor with a plant for the production of hydrogen from the working steam of a steam power process is suggested in which the working steam is heated up at low pressure using the high temperature of the helium circuit and the hydrogen is thus split off and separated. The working steam is then cooled down and the remaining heat is used for a tertiary process or recycled into the primary process.

(PROCESS HEAT REACTORS, PYROLYSIS)

H78 23402 MULTISTAGE THERMAL DECOMPOSITION PROCESS AND RADIATION DECOMPOSITION PROCESS OF WATER

(ISU, Tokyo, Japan), Latest Literature on Hydrogen Technology, 1975, EDB-77:144531, In Japanese

The principle and development of the processes for producing hydrogen from water by using nuclear fission energy, particularly those of the multistage decomposition process using nuclear heat and the radiation decomposition process using radiation energy, are described. This report is divided into five parts, namely: (1) the principle of thermochemical decomposition of water, (2) the thermodynamical functions for the substances related to the multistage thermochemical decomposition process, (3) the constitution of the multistage thermochemical decomposition process, (4) the reaction cycle and thermodynamical study of the multistage thermochemical decomposition process, and (5) the radiation decomposition process. The multistage thermochemical decomposition process is very interesting scientifically, but it has many problems to be solved to establish a new hydrogen production system. These problems are: (1) the thermal efficiency which is not always high, (2) the reaction of different phases, (3) too many stages of reaction, and (4) too much amount of material circulation. The important problem of the radiation decomposition process is the effort to improve the efficiency of energy. The decomposition of water and carbon dioxide are reviewed.

(CHEMICAL REACTION KINETICS)

H78 23601 HETEROGENEOUS SENSITIZED DECOMPOSITION OF WATER WITH SUNLIGHT. QUARTERLY PROGRESS REPORT, JANUARY 1 - MARCH 31, 1976

Ghosh, A.K., Maruska, H.P., (Exxon Research and Engineering Co., Linden, NJ), NSF/RA-760104, NSF ERP-75-13901, 40 p., N77-73525
Avail:NTIS

No abstract available

(CATALYSIS, ULTRAVIOLET RADIATION)

H78 23602 MATERIALS USED IN WATER PHOTOLYSIS TECHNIQUES OF SOLAR ENERGY CONVERSION

Haneman, D., (Univ. of New South Wales, Kensington, Australia), J. Australas Inst. Met., V 21:112-113, N2-3, 4 refs, June-Sept 1976

The presence of electron hole pairs are created by light in the semiconductor surface region, and are there separated by the surface region electric field. The holes (for an n type semiconductor with "upward" band bending) flow to the surface and capture electrons from OH- species in solution. The electrons flow out from a metal counter electrode and neutralize H+ ions to produce hydrogen, a storable fuel. Inexpensive materials can be employed for the semiconductor anode and the metal cathode in the cell. The material studied most extensively to date is titania (TiO_2). It has one major drawback: the bandgap of approximately 3 eV means that only wavelengths less than about 400 nm can be used, which is only 3% of the incident solar power.

(SEMICONDUCTOR).

H78 23603 PHOTOCATALYTIC REACTIONS. 1. PHOTOLYSIS OF WATER AND PHOTOREDUCTION OF NITROGEN ON TITANIUM DIOXIDE

Schrauzer, G.N., Guth, T.D., (Dep. Chem., Univ. California, La Jolla, CA), J. Am. Chem. Soc., V 99:7189-7193, N22, 1977

No abstract available

(POWDER MANUFG. STORAGE)

H78 23604 EFFICIENCIES OF VARIOUS METHODS FOR SOLAR ENERGY CONVERSION

Soper, W.G., (Office of Naval Research, London, England), 34 p., N77-83864
Avail:NTIS

No abstract available

(SYSTEM EFFECTIVENESS, THERMOCHEMISTRY)

H78 23605 PREPARATION OF HYDROGEN BY THERMAL DECOMPOSITION OF WATER. DEVELOPMENT OF NEW ENERGY CONVERSION METHODS

(Government Industrial Research Institute, Osaka, Japan), JITA Nyusu, V 91:20-21, 1977, In Japanese

No abstract available

(REVIEW)

H78 23801 SYNGAS PROCESS CONVERTS WASTE TO SNG

Feldmann, H.F., Felton, G.W., Nack, H., (Battelle Columbus Laboratories, Columbus, OH), Adlerstein, J., (Syngas Recycling Corp., Toronto, Canada), In Clean Fuels from Biomass and Wastes; Proceedings of the Second Symposium, Orlando, FL, Jan 25-28, 1977, Institute of Gas Technology, p. 311-321, 1977, (A78-11120 01-44), A78-11134

An experimental study of the production of raw gas containing substantial amounts of methane from municipal solid wastes is reported; the experimental system relies on a compact reactor scheme providing continuous production and short waste residence times. The system separates methane production from the gasification reaction zones, insuring that no methane is burned by oxygen or reformed by steam fed into the gasifier. Two types of reactor, employing either a free-fall or moving bed to segregate solids, are compared. The use of countercurrent gas-solids flow to recover heat from the raw product gases is also discussed.

(WASTE UTILIZATION, ENERGY TECHNOLOGY)

H78 23802 LABORATORY PROCEDURES TO DETERMINE THE NITROGEN CONTENT OF SOLID WASTES

Kaylor, W.H., Ulmer, N.S., (Bureau of Solid Waste Management, Cincinnati, OH), 49 p., N77-73535
Avail:NTIS
No abstract available

(CHEMICAL ANALYSIS, AGRICULTURE)

H78 23803 SYNTHETIC CARBONACEOUS FUEL AND FEEDSTOCK USING NUCLEAR POWER, AIR, AND WATER

Steinberg, M., Baron, S., (Brookhaven National Lab., Upton, NY), Int. J. Hydrogen Energy, V 2:189-207, N2, 13 refs, 1977

A system is proposed here for the production of synthetic carbonaceous fuels using nuclear power, air and water. Nuclear power is used to generate heat and electricity which is in turn used to decompose water thermally and electrolytically to produce hydrogen and oxygen. CO_2 is extracted from either or both the atmosphere and water. The hydrogen is combined thermocatalytically with CO_2 to produce methanol which is further thermocatalytically dehydrated to synthetic hydrocarbon fuels. The steps in the process are outlined.

(CARBON DIOXIDE, METHANOL)

H78 23804 PHYSICAL AND CHEMICAL PARAMETERS AND METHODS FOR SOLID WASTE CHARACTERIZATION OPEN-FILE PROGRESS REPORT

Ulmer, N.S., (Bureau of Solid Waste Management, Rockville, MD), 28 p., N77-72531
Avail:NTIS
No abstract available

(ANALYSIS, HYDROGEN, NITROGEN)

H78 23805 DEVELOPMENT OF A METHOD FOR THE DETERMINATION OF CARBON AND HYDROGEN IN SOLID WASTE

Wilson, D.L., (Bureau of Solid Waste Management, Cincinnati, OH), 38 p., N77-73729
Avail:NTIS
No abstract available

(DRYING APPARATUS, WASTE DISPOSAL)

H78 23806 PROCEDURE FOR THE MATHEMATICAL DETERMINATION OF TOTAL HEAT OF COMBUSTION CONTENT OF SOLID WASTES

Wilson, D.L., (Environmental Protection Agency, Cincinnati, OH), 15 p., N77-73702
Avail:NTIS
No abstract available

(DECOMPOSITION, INCINERATORS, OXIDATION)

H78 23807 LABORATORY PROCEDURE FOR THE GRAVIMETRIC DETERMINATION OF CARBON AND HYDROGEN IN SOLID WASTES (FOR METHODS MANUAL)

Wilson, D.L., (Bureau of Solid Waste Management, Cincinnati, OH), 40 p., N77-72520
Avail:NTIS
No abstract available

(COMBUSTION PRODUCTS)

H78 23808 CLEAN FUELS FROM BIOMASS AND WASTES: PROCEEDINGS OF THE SECOND SYMPOSIUM, ORLANDO, FL, JANUARY 25-28, 1977

(Institute of Gas Technology, Chicago, IL), Symposium sponsored by the Institute of Gas

Technology, Chicago, IL, Institute of Gas Technology, 528 p., 1977, for individual items see A78-11121 to A78-11139, A78-11120

The use of biomass and wastes as a source of fuel is studied, with attention given to land requirements of biomass plantations, the application of forest biomass to energy production, hydrogen production through photolysis, ethanol-gasoline automotive fuels, the conversion of solid-waste cellulose to glucose, genetic engineering to improve plant photosynthesis rates, and the operation of a 100,000-gallon anaerobic digester to treat municipal solid wastes. Other topics discussed include the design of a compact reactor to produce methane from solid wastes, the efficiency of several pyrolytic processes, the gasification of biomass and wastes with a rotary kiln, the production of methane through fermentation of microalgae in waste water treatment ponds, and the culture and processing of waterhyacinths.

(ENERGY PRODUCTION, ECONOMIC FACTORS)

III. UTILIZATION

H78 30001 RAW MATERIALS FOR SPACE MANUFACTURING - A COMPARISON OF TERRESTRIAL PRACTICE AND LUNAR AVAILABILITY

Caulkins, D., (British Interplanetary Society), Journal - Space Colonization, V 30:314-316, Aug 1977, A77-46774

A brief comparison between the raw materials necessary for industrial production on earth, and their availability on the moon for space manufacturing is presented and graphed on a chart contrasting each element as to its per capita and metric ton usage on earth, and the percentage of abundance on lunar soil. It was found that among the most important raw materails not available on the moon are carbon, hydrogen, nitrogen, and copper. Substitutes for wood, paper, and plastics will need to be developed.

(ABUNDANCE, INDUSTRIES, METALS)

H78 30002 A NEW CYCLE FOR OPTIMUM ENERGY STORAGE IN INTERPLANETARY MISSIONS

Igenbergs, E., (Muenchen, Technische Universitaet, Munich, West Germany), International Astronautical Federation, International Astronautical Congress, 28th, Prague, Czechoslovakia, 40 p., Sept 25 - Oct 1, 1977, A77-51444

An investigation is conducted concerning an approach in which a spacecraft on a mission obtains energy from nuclear power plants or by the utilization of solar radiation and stores this energy for an employment in energy-consuming operations to be performed at a later time. In a brief analysis it is demonstrated, in a comparison of various possibilities that, of the considered systems, only a system which stores energy chemically in the form of elementary oxygen and hydrogen, obtained from water, provides a feasible low-weight energy storage method. A solar mirror-turbine/generator system and a system obtaining electric energy for the decomposition of water by means of solar cells are considered. The water formed, when the stored energy is withdrawn for use, is retained and can be employed again for additional energy-storage cycles. Formulas and graphs are presented which illustrate the suitability of the discussed techniques for a number of spacecraft missions, giving particular attention to interplanetary missions to mars and venus.

(SPACECRAFT POWER SUPPLIES, SOLAR CELLS)

H78 30003 THE ELECTRICAL POWER SYSTEM FOR SPACELAB

Gohrbandt, B., Schmidt, E.F, (Telefunken Ag, Hamburg, West Germany), In Space and Energy; Proceedings of the Twenty-Sixth International Astronautical Congress, Lisbon, Portugal, p. 29-43, September 21-27, 1975, Pergamon Press, Oxford and New York, p. 29-43 1977, A77-46787 22-12, A77-46789

Following an overview of the spacelab's mission requirements, such as its general weight, power consumption, and heat dissipation, the electrical power and distribution subsystem (EPDS) is described in full with subsystem design requirements and primary design criteria listed. A block diagram of the EPDS is shown and separate presentations are made for the following features: (1) the power conditioning and distribution concepts, (2) power sources, (3) power conditioning equipment, (4) power distribution, monitoring and protection, (5) the emergency power system, (6) the lighting system, and (7) signal conditioning. It is concluded that the EPDS provides the flexibility necessary for various payloads and configurations of the spacelab mission.

(HYDROGEN OXYGEN FUEL CELLS, LIGHTING EQUIPMENT)

H78 30004 TECHNOLOGY REQUIREMENTS FOR ADVANCED EARTH-ORBITAL TRANSPORTATION SYSTEMS SUMMARY REPORT - SINGLE STAGE TO ORBIT VEHICLES. Final Report

Haefeli, R.C., Littler, E.G., Hurley, J.B., Winter, M.G., (Martin Marietta Corp., Denver, CO), NASA-CR-2867, 62 p., N77-33255
Avail:NTIS

Areas of advanced technology that are either critical or offer significant benefits to the development of future earth-orbit transportation systems were identified. Technology assessment was based on the application of these technologies to fully reusable, single-state-to-orbit (SSTO) vehicle concepts with horizontal landing capability. Study guidelines included mission requirements similar to space shuttle, an operational capability beginning in 1995, and main propulsion to be advanced hydrogen-fueled rocket engines. The technical and economic feasibility of this class of SSTO concepts were evaluated as well as the comparative features of three operational take-off modes, which were vertical boost, horizontal sled launch, and horizontal take-off with subsequent inflight fueling. Projections of both normal and accelerated technology growth were made. Figures of merit were derived to provide relative rankings of technology areas. The influence of selected accelerated areas on vehicle design and program costs was analyzed by developing near-optimum point designs.

(HYDROGEN FUELS, ROCKET ENGINES)

H78 30005 DEVELOPMENT PROGRESS OF HM 7 LO_x/LH_2 ROCKET ENGINE FOR THE ARIANE THIRD STAGE PROPULSION SYSTEM

Pouliquen, M., (Societe Europeenne de Propulsion, Vernon, France), International Astronautical Federation, International Astronautical Congress, 28th, Prague, Czechoslovakia, 13 p., Sept 25 - Oct 1, 1977, A77-51426

The development of the 6000 Dan Thrust HM 7 rocket engine which will power the third stage of the ariane launcher is described. In addition to producing thrust, the HM 7 has to allow pitch and yaw control by gimballing, heat gaseous helium for LO_x tank pressurization, and supply regenerated gaseous hydrogen for LH_2 tank pressurization and for the vehicle attitude and roll control system. The test program and test facilities are described, and component test results are considered with attention to thrust chamber, turboprop and components, accessories, and pyrotechnics. Integrated engine testing involved sea level horizontal tests, sea level vertical tests, altitude simulation tests, and vibration tests. A summary of the main problems encountered and their solutions is provided.

(LIQUEFIED GASES, PYROTECHNICS, TEST FACILITIES)

H78 30006 GENESIS OF LIQUID HYDROGEN PROPULSION THROUGH 1945

Sloop, J.L., (International Astronautical Federation), International Astronautical Congress, 28th, Prague, Czechoslovakia, 9 p., Sept 25 - Oct 1, 1977, A77-51512

Early enthusiasm manifested by pioneers (Tsiolkovskii, Goddard, Oberth) in gaseous and liquid hydrogen as rocket propellant is recalled. Advantages (high exhaust velocity, availability, mass ratio, energy) and discouraging drawbacks (low density and mass, large storage volume, difficulty in handling, poor performance in combustion engines) experienced at the time are recounted. Early experience with liquefied hydrogen and probes in this area three decades ago are recalled.

(FUELS, SPACECRAFT)

H78 31001 ALTERNATE FUELS FOR FUTURE AIRCRAFT

Brewer, G.D., (Lockheed-California Co., Burbank, CA), In Intersociety Energy Conversion Engineering Conference, 12th, Washington, DC, August 28 - September 2, 1977, Proceedings, American Nuclear Society, Inc., La Grange Park, IL, V 1:62-68, 1977, A77-48701 23-44, A77-48709

The paper mentions some results of comparisons of the applicability of liquid hydrogen-fueled aircraft of the future and equivalent aircraft fueled with Jet A. Liquid hydrogen-fueled aircraft show clear superiority stemming from better lift-to-drag ratio in cruise and the specific fuel consumption realized during cruise. These advantages are retained when supersonic transport aircraft are considered as well. At the moment, studies indicate that it would cost more to build and operate a hydrogen-fueled fleet than a fleet fueled with synthetic Jet A, but if one takes into account projected improvements in the production process for liquid hydrogen (hydrogen gasification) and for synthetic Jet A, the LH_2-fueled aircraft comes out ahead.

(LIQUID HYDROGEN, SUPERSONIC TRANSPORTS)

H78 31002 HYDROGEN ENRICHMENT FOR LOW EMISSION JET COMBUSTION

Clayton, R.M., (Jet Propulsion Lab., Pasadena, CA), Prepr., Div. Pet. Chem., Am. Chem. Soc., V 22:178-198, N1, Feb 1977, EDB-77:144190

The feasibility of hydrogen enrichment in jet combustors is evaluated. Based on interim results it is concluded that ultralow target emission levels were simultaneously achieved under simulated cruise power conditions at a burning equivalence ratio (ER) and with pressure losses amenable to practical combustor design. These levels were achievable with the MOD 2 burner with H_2 enrichment, but not with jet fuel only due to the onset of lean blowout at too high an ER to sufficiently reduce the NO_x emission. Premixing deficiencies, particularly with regard to the H_2, reduced the effectiveness of H_2 enrichment and aggravated the flameholder durability problems in these experiments. Improved premixing should reduce the amount of H_2 required. As reactant mixing is improved, the potential of lean burning for minimizing NO_x will be approached, but maintaining flame stabilization and ultralow HC and CO emissions will become limiting practical considerations. Hydrogen enrichment can provide a significant lean-limit extension for minimizing all emissions. Flame stabilization via a physical flameholder presents a difficult design/development problem due to the exposure of the component to the combustion zone. On the other hand, true achievement of the lowered combustion temperature potentially available with H_2 enrichment should reduce the heat load to the exposed surfaces compared, for example, to present linear environments. Alternative flame stabilization schemes might also alleviate the problem. Effective implementation of H_2 enrichment is not simple but is feasible with dedicated development. Importantly, the bulk of the premixing problem has to be solved for any lean-burning scheme.

(POLLUTION CONTROL, FUEL FEEDING SYSTEM)

H78 31003 THE LIQUID HYDROGEN OPTION FOR THE SUBSONIC TRANSPORT - A STATUS REPORT

Korycinski, P.F., (NASA, Langley Research Center, Hampton, VA), In Intersociety Energy Conversion Engineering Conference, 12th, Washington, DC, August 28-September 2, 1977, Proceedings, American Nuclear Society, Inc., La Grange Park, IL, V 1:964-972, 1977, A77-48701 23-44, A77-48819

Studies dealing with the use of liquid hydrogen for fuel in subsonic air transport systems are reviewed. Topics of the studies include the possibility for economical production of hydrogen, the problems associated with the efficient liquefaction of the gas, the development of insulation materials and materials for long-lasting liquid hydrogen fuel tanks, the difficulties related to fueling processes and the installation of liquid hydrogen fuel stations at major air terminals, an assessment of the hazards connected with liquid hydrogen fuels, and the engineering and design problems involved in incorporating liquid hydrogen fuel systems into large subsonic passenger aircraft.

(ENERGY TECHNOLOGY, SYNTHETIC FUELS)

H78 31004 THE MILITARY UTILITY OF VERY LARGE AIRPLANES AND ALTERNATIVE FUELS

Mikolowsky, W.T., (Rand Corp., Washington, DC), Noggle, L.W., (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH), Stanley, W.L., (Rand Corp., Santa Monica, CA), Astronautics and Aeronautics, V 15:46-56, Sept 1977, A77-47271

The paper describes a study with the objectives of evaluating very large airplanes (VLA's) in the context of existing and possible future Air Force missions and determining the most attractive alternative fuel for these airplanes. The chemical fuel alternatives considered are liquid hydrogen, liquid methane, and synthetic JP, each of which can be readily synthesized from coal. The nuclear-fueled VLA was a fourth candidate aircraft. The cost and energy effectiveness of these basic aircraft-fuel combinations in typical range, radius, and station-keeping missions was estimated. It was concluded that overall, a conventional hydrocarbon jet fuel remains the most attractive fuel for military aircraft. Nuclear propulsion is attractive only for station-keeping missions requiring large station radii. VLA's are especially attractive if the capability to airlift U.S. forces world-wide without reliance on overseas bases is a major requirement.

(JET ENGINE FUELS, LIQUID HYDROGEN)

H78 31005 AN EVALUATION OF VERY LARGE AIRPLANES AND ALTERNATIVE FUELS. INTERIM REPORT

Mikolowsky, W.T., Noggle, L.W., Hederman, W.F., Horvath, R.E., (Rand Corp., Santa Monica, CA), Dec 1976, AD-A-040532, EDB-77:146215

Very large airplanes using alternative fuels are examined in the context of existing and possible future Air Force missions. Synthetic jet fuel (JP), liquid methane, liquid hydrogen, and nuclear propulsion are the fuel alternatives selected for detailed analysis. Conceptual designs of airplanes using each of these fuels were developed and estimates were made of their lifecycle cost and life-cycle energy consumption. Mission analyses were performed to determine the effectiveness of the alternative airplanes in strategic airlift specifically and in the station-keeping role in general. Results indicate that for most military applications airplanes with gross weights in excess of one million pounds promise to be superior to any contemporary airplanes in terms of cost-effectiveness and energy-hydrocarbon jet fuel, whether manufactured from oil shale, coal or crude oil, remains the most attractive aviation fuel for future Air Force use. Policy recommendations are made pertaining both to alternative fuels and to advanced-technology large airplanes. Future research and developments are also identified.

(EVALUATION, LIFE-CYCLE COST, TECHNOLOGY ASSESSMENT)

H78 31006 FUEL SUBSYSTEM FOR LH_2 AIRCRAFT: R & D REQUIREMENTS

Momenthy, A.M., (Boeing Commercial Airplane Co., Seattle, WA), Int. J. Hydrogen Energy, V 2:155-162, N2, 1977, EDB-77:137394

Design characteristics of the fuel subsystem for subsonic LH_2 fueled aircraft are discussed in terms of requirements and technology availability. Some of the differences between LH_2 systems developed for space vehicles and those required for commercial aircraft are pointed out. Significant areas of technology requiring advancement and long lead time development testing are identified. The material presented in this paper reflects the results obtained form a Boeing study covering the development of a candidate fuel subsystem for a 3000 nautical mile range LH_2 fueled commercial airplane.

(DESIGN, HYDROGEN FUELS)

H78 32001 REFUELING HYDROGEN TRANSIT FLEETS: PART A: ECONOMICS

Beyer, R.B., Woolley, R.L., (NASA, Lewis Research Center, Cleveland, OH), (Billings Energy Corp., Provo, UT), Fourth International Symposium on Automotive Propulsion Systems, V II, CONF-770430, EDB-77:140241

The economics of several hydrogen manufacturing, distribution, and use strategies are evaluated for a fleet of converted buses for the purpose of setting a guide in selection of feasible methods for refueling. The most attractive alternative is pipeline distribution of hydrogen produced from gasified coal and water for use in feti hydride vehicles. A system based on existing technology is estimated to cost midway between the current cost of gasoline (U.S.) and the predicted cost of synthetic gasolien from coal. A hydrogen bus fleet supplied by pipeline will have a lower total cost than systems using other synthetic fuels derived from coal.

(BUSES, COAL GASIFICATION, EVALUATIONS)

H78 32002 RESULTS OF HYDRIDE RESEARCH AND THE CONSEQUENCES FOR THE DEVELOPMENT OF HYDRIDE VEHICLES

Buchner, H., Saeufferer, H., (NASA, Lewis Research Center, Cleveland, OH), (Daimler-Benz Ag, Stuttgart, Germany), Fourth International Symposium on Automotive Propulsion Systems, V II, 1977, CONF-770430-P2(draft), EDB-77:140238

From the results attained with the hydride-powered vehicles and hydride development at Daimler-Benz it can be demonstrated that hydrogen storage in metal hydrides for virtually nonpollutive automotive propulsion systems has a number of system-specific advantages which, to some extent at least, make up for the relatively adverse weight proportions of the storage tank as compared to liquid hydrocarbons. Provided that suitable hydrides are chosen, the hydride tank assumes at least the following four functions at the same time: (1) fuel supply, (2) air-conditioning, (3) water condensation, and (4) storage of waste heat from the engine. The hydrogen powered vehicle equipped with an internal combustion engine and hydride storage system is thus extremely advantageous for the environment. Its range of operation varies between 200 KM and 400 KM. Although a hydrogen infrastructure comparable to the network of filling stations for liquid hydrocarbons does not exist, setting up a hydrogen supply system of any desired size, e.g., for municipal vehicle fleets, would be technically feasible within a very short time, using, e.g., the steam reforming process of natural gas.

(AUTOMOTIVE FUELS, HYDROGEN STORAGE)

H78 32003 ALTERNATIVE FUEL FOR CARS

Chatterjee, J.S., Som, P., (Jadavpur Univ., Calcutta, India), Electron. Power, V 22: 528-529, N8, Aug 1976, EDB-77:131011

The solutions suggested for the car energy-storage problem are the use of an improved version of the battery for power storage or the use of hydrogen as a fuel. The weight of a battery for a long traction mileage is prohibitively high. To use hydrogen as a fuel for cars, the problems of easy and cheap production and safe storage need to be solved. The chemistry for hydrogen production is outlined and the total power demand for the system is discussed. A comparison is made between the weight of raw materials necessary for producing hydrogen fuel and the petroleum weight for identical heat of combustion.

(CHEMISTRY, COST, ENERGY STORAGE)

H78 32004 COMPARATIVE EFFICIENCIES OF ALTERNATIVE FUTURE AUTOMOTIVE POWER SYSTEMS

Fetterman, G.P., Jr., Mauri, G., Ricci, R.L., (NASA, Lewis Research Center, Cleveland, OH), (Exxon Enterprises Inc., Florham Park, NJ), Fourth International Symposium on Automotive Propulsion Systems, V IV, 1977, CONF-770430, EDB-77:140150

An analysis is given of the overall energy efficiency of a small (2 + 2) urban vehicle powered by five different powertrains, all with similar acceleration performance and payload capabilities. The drivetrains compared are: a hydrogen-fueled-spark-ignition engine, an advanced gasoline-fueled-spark-ignition engine, a diesel engine, a diesel/electric hybrid, and a pure electric with an advanced motor/controller and battery. The test weight of each vehicle is varied so that differences in both power system weight and chassis weight propagation are reflected. Each vehicle is mathematically modeled and driven over the EPA urban driving cycle so that its road load energy requirements are generated. The energy usage of each vehicle is then traced through its drivetrain and fuel processing efficiencies and measured in terms of raw energy in the ground. Estimates are made of the energy used in the production of each vehicle, and the total life cycle energy consumption is calculated.

(DIESEL ENGINES, ENERGY CONSUMPTION)

H78 32005 CRYOGENIC FUEL SYSTEMS FOR MOTOR VEHICLES

Hibl, J.J., (Beech Aircr. Corp., Boulder, CO), Adv. Cryog. Eng., V 21:180-186, 9 refs, 1975, EDB-77:127832

Alternative fuels for motor vehicles are needed to help satisfy the nation's enormous appetite for transportation fuels. Cryogenic liquids - liquefied natural gas and liquid hydrogen - are candidate fuels. Liquefied natural gas (LNG) is attractive for the near term, while hydrogen is projected to be "the fuel of the future". Both cryogens offer important advantages over other fuels now in use or being considered. Both are low-polluting and have a high energy content per unit weight. In view of the advantages posed by these cryogens as fuels, a program was undertaken to develop storage containers for these fuels and demonstrate the supply system on motor vehicles. This presentation describes the tank and flow system development, including operating experience.

(DESIGN, ENGINEERING, PERFORMANCE TESTING)

H78 32006 ECONOMY OF HYDROGEN-FUELED AUTOMOBILE ENGINES

MacKay, D.B., (Billings Energy Res. Corp., Provo, UT), Monogr. on Alternate Fuel Resour. Based on Pap. Presented at the Symp on Alternate Fuel Resour., Santa Maria, CA, Mar 25-27, 1976, Publ by West Period Co., North Hollywood, CA, AIAA, V 20:294-301, 1976

Reduction of energy consumption is possible for engines using hydrogen fuel, as compared to those using gasoline. Hydrogen engines can be made with high compression ratios, and thus can attain high thermal efficiencies at all loads and speeds. In addition, it is possible to vary hydrogen-air mixture ratios to achieve load control. Lean mixtures at part loads improve thermodynamic performance and reduce pumping losses. For these reasons considerable energy savings are possible, particularly at part loads and lower speeds. The engine used for comparison showed approximately a 20 percent increase in mileage per unit of energy at 60 miles per hour, and double mileage at 20 miles per hour. These results have been substantiated on an automobile tested at Billings Energy Research Corporation. This economy is possible while creating essentially no atmospheric pollution.

(FUEL ECONOMY, THERMODYNAMIC PERFORMANCE)

H78 32007 STUDY ON REFORMED FUEL FOR AN AUTOMOTIVE GASOLINE ENGINE

Noguchi, M., Bunda, T., Sumiyoshi, M., Kageyama, J., Yamaguchi, S., (NASA, Lewis Research Center, Cleveland, OH), Fourth International Symposium on Automotive Propulsion Systems, V II, 1977, CONF-770430-P2(draft), EDB-77:140239

The Jet Propulsion Laboratory has reported on a method which allows an IC engine to operate at a super lean A/F ratio by using a hydrogen supplemented fuel. This makes possible a reduction in NO_x emissions as well as an improvement in fuel economy. Applying this method to a carbureted three valve prechamber engine, a low NO_x emission level and improved fuel economy can be expected with a smaller amount of hydrogen because of the combined effects of the hydrogen supplement and the inherent low NO_x emission characteristics of the engine. A prototype on-board fuel reformer was developed and laboratory tests were conducted to determine the effects of the amount of reformed fuel on combustion. The results of these tests are discussed. On the Japanese test cycle, an extremely low NO_x emission level was attained with relatively good fuel economy. However, in a limited combination of engine size and vehicle weight, engine power was sacrificed somewhat because of this lean combustion. A solution to this problem, while maintaining the lower NO_x emission level, is to adopt a richer air-fuel ratio and a higher EGR rate. In this approach, the amount of hydrogen must be increased to improve combustion stability. For this purpose, methanol reforming was introduced whereby the additional hydrogen was supplied without any deterioration in energy efficiency.

(HYDROGEN PRODUCTION, ROAD TESTS)

H78 32008 VEHICLE TEST AND EVALUATION PROGRAM OF THE U.S. POSTAL SERVICE

Norman, T.A., Divacky, R.J., (NASA, Lewis Research Center, Cleveland, OH), (U.S. Postal Service, Rockville, MD), Fourth International Symposium on Automotive Propulsion Systems, V 5, 1977, CONF-770430-P5(draft), EDB-77:140152

The U.S. Postal Service has a vested interest in engines and vehicle systems which, when used in the delivery and transportation of mail, will minimize the use and dependence upon oil based fuels and will offer minimum life cycle costs. In the light duty internal combustion engine area, diesels, stratified charge and hydrogen fueled engines, along with a gasoline / electric hybrid propulsion system were scheduled for engineering evaluation. Test results on the diesel and stratified charge engines show a significant increase in fuel economy over the presently used gasoline engine. Tests on the gasoline engine / electric hybrid system indicate the need for major component design before achieving operational data. Analysis and laboratory tests conducted thus far on the hydrogen fueled engine indicate potential for higher efficiency, comparable small, low performance gasoline engines will be evaluated.

(DIESEL ENGINES, FUEL ECONOMY)

H78 32009 HYDROGEN STORAGE IN VEHICLES - AN OPERATIONAL COMPARISON OF ALTERNATIVE PROTOTYPES

Woolley, R.L., Simons, H.M., (Billings Energy Res Corp., Provo, UT), SAE Prepr., 9 p., N760570 for Meet, 13 refs, June 7-10, 1976

Performance parameters of several prototype containers for storing hydrogen are described. A cryogenic vessel and three metal hydride containers of similar design but different size have been used in automotive service. Hydrogen release rates were controlled to match with engine demand. All prototypes were able to sustain a steady state flow rate sufficient for vehicle operation at normal cruise speed. In order to illustrate the principle of hydride operation, a pressure - temperature history for recharge of a small portable hydride tank is given along with several discharge curves with and without heating.

(FUEL TANKS, AIR POLLUTION)

H78 32010 REFUELING HYDROGEN TRANSIT FLEETS: PART B: DATA

Woolley, R.L., Beyer, R.B., Rappleye, J., (NASA, Lewis Research Center, Cleveland, OH), (Billings Energy Corp., Provo, UT), Fourth International Symposium on Automotive Propulsion Systems, V II, 1977, CONF-770430-P2(draft), EDB-77:140242

Data collected while refueling a prototype hydrogen bus are discussed. The refueling operation more severely limits the design of the vehicle tanks than does the discharge condition, since the heat transfer must be accomplished in a shorter time. These data indicate that 30 minutes is an attainable refueling period. A significant fraction (40 percent) of the refueling takes place without heat transfer as the hydride increases in temperature. This characteristic can be enhanced and used to advantage such that a fleet based on an hourly quick-recharge will have a lower operational cost. Sorption characteristics and thermal conductivity for the FeTi hydride used in the vehicle are reported.

(BUSES, COST, IRON HYDRIDES)

H78 32011 LEAN COMBUSTION IN AUTOMOTIVE ENGINES. AN ASSESSMENT OF THE ADDITION OF HYDROGEN TO GASOLINE AS COMPARED TO OTHER TECHNIQUES

(Aerospace Corp., El Segundo, CA), 234 p., N77-82436
Avail:NTIS

No abstract available

(FEASIBILITY ANALYSIS)

H78 33001 EMISSIONS AND TOTAL ENERGY CONSUMPTION OF A MULTICYCLINDER PISTON ENGINE RUNNING ON GASOLINE AND A HYDROGEN-GASOLINE MIXTURE

Cassidy, J.F., (NASA, Lewis Research Center, Cleveland, OH), May 1977, EDB-77:146090, N77-23114
Avail:NTIS

A multicylinder reciprocating engine was used to extend the efficient lean operating range of gasoline by adding hydrogen. Both bottled hydrogen and hydrogen produced by a research methanol steam reformer were used. These results were compared with results for all gasoline. A high-compression-ratio, displacement production engine was used. Apparent flame speed was used to describe the differences in emissions and performance. Therefore, engine emissions and performance, including apparent flame speed and energy lost to the cooling system and the exhaust gas, were measured over a range of equivalence ratios for each fuel. All emission levels decreased at the leaner conditions. Adding hydrogen significantly increased flame speed over all equivalence ratios.

(FUEL CONSUMPTION, MIXTURES, PERFORMANCE TESTING)

H78 33002 PERFORMANCE OF HYDROGEN-FUELED RECIPROCATING ENGINES

Cole, R.B., (NASA, Lewis Research Center, Cleveland, OH), (Stevens Inst. of Tech., Hoboken, NJ), Fourth International Symposium on Automotive Propulsion Systems, V II, 1977, CONF-770430-P2(draft), EDB-77:140236

The thermodynamics and emissions performance of diverse experimental engines fueled with hydrogen is summarized and compared with theoretical (fuel/air cycle) analysis of such engines. Most of the experimental data are from naturally-aspirated spark-ignition engines though several data sets are from fuel-injected engines. The data are found to be highly consistent with fuel/air-cycle analysis, and it is concluded that fuel/air-cycle analysis provides both: (1) an apt (if often neglected) baseline against which to compare both past and future engine performance data and also, (2) a suitable basis for describing the potential performance of hydrogen-fueled engines.

(COMBUSTION PRODUCTS, THERMODYNAMICS, MIXTURES)

H78 33003 CHARACTERISTICS OF A SINGLE CYLINDER HYDROGEN-FUELED IC-ENGINE USING VARIOUS MIXTURE FORMATION METHODS

Drexl, K.W., (Daimler-Benz Ag, Stuttgart, Germany), Gutmann, M., Holzt, H.P., (NASA, Lewis Research Center, Cleveland, OH), Fourth International Symposium on Automotive Propulsion Systems, V II, 1977, CONF-77-0430, EDB-77:140237

A survey is given of research work on hydrogen engines at Daimler-Benz. It is shown that the output of the engine depends on the mixture formation method used. Direct injection of hydrogen into the cylinder results in a gain in B.M.E.P. as compared with mixture formation in the intake pipe. The engine operational parameters were set to reach minimum fuel consumption and minimum emissions. This involves combined quality/quantity-control and a compression ratio of 7:1 to avoid knocking at stoichiometric air/fuel-ratios.

(FUEL-AIR RATIO, SPARK IGNITION)

H78 33004 COMBUSTION ENGINE - FOR AIR POLLUTION CONTROL

Houseman, J., (NASA, Pasadena Office, CA), (Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena, CA), NASA-CASE-NPO-13671-1, 9 p., N77-31497

An arrangement for an internal combustion engine is provided in which one or more of the cylinders of the engine are used for generating hydrogen rich gases from hydrocarbon fuels, which gases are then mixed with air and injected into the remaining cylinders to be used as fuel. When heavy load conditions are encountered, hydrocarbon fuels may be mixed with the hydrogen rich gases and air and the mixture is then injected into the remaining cylinders as fuel.

(CARBURETORS, FUEL-AIR RATIO)

H78 33005 DIRECT-CONNECT TESTS OF HYDROGEN-FUELED SUPERSONIC COMBUSTORS

Waltrup, P.J., Dugger, G.L., Billig, F.S., Orth, R.C., (Johns Hopkins Univ., Laurel, MD), In Symposium on Combustion International, 16th, Cambridge, MA, Aug 15-29, 1976, Proceedings, Combustion Institute, Pittsburgh, PA, p. 1619-1629, 1977, NASA-supported, A77-48158 23-25, A77-48240

Direct-connect tests of hydrogen-fueled supersonic combustors were performed using arc-heated air at combustor inlet mach numbers of 2.9 to 3.2. Various axisymmetric combustor geometries of 5.89 and 6.96 CM (inner diameter) inlet were investigated; the fuel was injected from the wall either from a ring of equally spaced holes normal to the air stream, or from a circumferential slot oriented 45 degrees downstream. The hole-type injectors consistently gave better results. The effects of various parameters are examined, and the performance comparison procedure is described. A theoretical model of the supersonic combustion process which includes a precombustion shock-compression is used to explain the character of the observed pressure distributions and to assess the effects of the measured heat transfer rates, deduced wall shear, and combustor geometry on performance.

(HEAT TRANSFER, TEMPERATURE EFFECTS)

H78 33006 HYDROGEN ENGINE/NO_x CONTROL BY WATER INDUCTION

Woolley, R.L., Anderson, V.R., (NASA, Lewis Research Center, Cleveland, OH), (Billings Energy Corp., Provo, UT), Fourth International Symposium on Automotive Propulsion Systems, V 5, 1977, CONF-770430-P5(draft), EDB-77:140245

Water induction in a hydrogen engine is an effective means to reduce production of oxides of nitrogen and also to suppress flashback. Two methods of inducting the water are compared: (1) spraying into the air-hydrogen mixture in the intake manifold and (2) spraying into the hydrogen stream prior to mixing with air. The second method is considerably more effective. Power and efficiency are essentially unaffected by water addition. This makes possible a very simple on/off design that is switched by the engine throttle.

(MIXING, EXHAUST, SPARK IGNITION)

H78 33007 AN EXPERIMENTAL INVESTIGATION OF COMBUSTION PERFORMANCE OF LO_x/GH_2 ROCKET COMBUSTOR WITH COAXIAL INJECTORS

Suzuki, A., Yatsuyanagi, N., Gomi, H., Sakamoto, H., (National Aerospace Lab., Tokyo, Japan), 35 p., N77-79931, In Japanese, English summary
Avail:NTIS
No abstract available

(EFFICIENCY, FUEL INJECTION)

H78 34001 FUEL CELL TECHNOLOGY PROGRAM

Bell, D., (NASA, Manned Spacecraft Center, Houston, TX), July 1970, EDB-77:146018, N70-40974
Avail:NTIS
No abstract available

(FABRICATION, MATERIALS, PERFORMANCE TESTING)

H78 34002 NICKEL-HYDROGEN STORAGE BATTERY FOR USE ON NAVIGATION TECHNOLOGY SATELLITE-2

Betz, F., Stockel, J., Gaudet, A., (Naval Res. Lab., Washington, DC), Eleventh Intersociety Energy Conversion Engineering Conference, p. 510-516, 10 refs, 1976, Amer. Inst. Chem. Engrs., New York

Naval Research Laboratory (NRL) and intelsat have entered into an agreement to flight test a nickel-hydrogen battery. Intelsat is providing the nickel-hydrogen cells, NRL is integrating these cells into the spacecraft energy storage system. This paper presents a description of the nickel-hydrogen cells. Design features include electrochemically impregnated positive electrodes, asbestos separators, and teflon-backed platinum negative electrodes. The flight mission plan is to use the nickel-hydrogen battery as the prime power source during eclipse periods in a medium-altitude satellite with a 3-year minimum life. The mission requires full load operation of approximately 325 W through all eclipses. The thermal design objective was to maintain the battery temperature between 0 degrees and 24 degrees during normal operation. Results of thermal vacuum testing have verified the design objectives and the use of temperature for charge control.

(SPACECRAFT ENERGY)

H78 34003 TARGET CAPITAL COSTS FOR THE IMPLEMENTATION OF FUEL CELLS AND ELECTRIC STORAGE DEVICES WITHIN THE NATIONAL ENERGY SYSTEM

Braun, C., Cherniavsky, E.A., Salzano, F.J., (Brookhaven National Lab., Upton, NY), Electrochemical Society, Inc., Philadelphis, PA, 1976, EDB-77:127657

The allowed capital cost for the introduction of fuel cells and electric storage devices into the year 1985 National Energy System are examined, utilizing the Brookhaven Energy System Optimization Model (BESOM). The storage devices are characterized by their overall electric-to-electric conversion efficiencies and by their expected lifetimes which are varied parametrically over the entire range of feasible efficiencies and lifetimes. Electric storage devices are considered as peaking plants, operating at load factors of 0.050, 0.10, and 0.20. The possible introduction of electric storage plants to intermediate load service at a load factor of 0.50 and to both intermediate and peaking load generation when operating on a weekly instead of a daily cycle, is also considered. The capital costs at which these devices become economically attractive are calculated using the marginal values obtained from the linear programming problem solution. The break-even capital costs (which include capitalized operation and maintenance expenditures) are computed as a function of the conversion efficiencies and expected lifetime for various residual and distillate fuel oil prices.

(COAL GASIFICATION, POWER DEMAND)

H78 34004 HYDROGEN-AIR FUEL CELLS

Breelle, Y., Cheron, J., DeGobert, P., Grehier, A., Rev. Gen. Electr., France, V 86:24-30, N1, Jan 1977, In French

Following an explanation of hydrogen-air fuel cell principles and of its building and operating features, the progress made in this field during years 1967-1977 is discussed, e.g., increased electrode performances, progress in fuel-cell building techniques and batteries auxiliary equipment. The interest of hydrogen-air fuel cell is enhanced by the future prospects of hydrogen as a widespread available fuel, due to the nuclear plant development. Fuel cell batteries are expected to be used as autonomous power units (power capacity greater than 400 WH/KG) and in automotive electric traction.

(ENERGY CONVERSION)

H78 34005 FUEL CELL RELIABILITY ASSESSMENT. QUARTERLY PROGRESS REPORT, JULY 8 - OCTOBER 8, 1967

Bruno, R.P., (Allis-Chalmers Mfg. Co., Milwaukee, WI), V 29, 2 KW units, Nov 25, 1967, EDB-77:146023, N68-11827
Avail:NTIS $3.00
No abstract available

(FLOW REGULATORS, SERVICE LIFE)

H78 34006 TOWARD IMPROVED PRIMARY ELECTROCHEMICAL POWER SYSTEMS

Cohn, E.M., (NASA, Washington, DC), 1967, EDB-77:146017, N68-27684
Avail:NTIS $3.00
No abstract available

(ALCOHOL FUEL CELLS, STORAGE LIFE)

H78 34007 NEW MATERIALS FOR FLUOROSULFONIC ACID ELECTROLYTE FUEL CELLS. Final Technical Report, OCT 7, 1974 - APR 7, 1977

George, M., Januszkiewicz, S., (Energy Research Corp., Danbury, CT), 49 p., N78-12531
Avail:NTIS
Hydrogen-air fuel cells were evaluated with both TFMSA monohydrate and dilute TFMSA. Pressurized monohydrate cells were run at power levels comparable to phosphoric acid fuel cells under similar conditions. Fuel cells with from 25 to 60% TFMSA were evaluated at 25 and 70°C. A cell with 50% TFMSA was run for over 2,000 hours at room temperature without acid replenishment. Power densities in excess of 130 MS/SQ CM could be achieved at ambient temperatures and pressures with low loading catalysts. The evaluation of supported platinum and tungsten carbide catalyst with dilute TFMSA was initiated. Silicon carbide was investigated as a matrix material with TFMSA.

(ELECTROCATALYSTS, SILICON CARBIDES)

H78 34008 SOLID-ELECTROLYTE BATTERY, PARTICULARLY FOR THE STORAGE OF ELECTRICAL ENERGY

Rohr, F.J., U.S. Patent 4,038,462, July 26, 1977, Patent also relevant to fuel cells, EDB-77:139706
A solid-electrolyte battery, particularly for the storage of electrical energy, has at least one anode space and one cathode space forming electrode spaces, which are connected with one another by ionic conduction through a solid electrolyte and have collecting and equalizing spaces for the reactants and reaction products. The solid-electrolyte battery includes a number of parallel-connected, hole-like electrode spaces including anode and cathode spaces, which are bounded by the solid electrolyte and distributed alternately and close together, so that each of the electrode spaces presents reaction surfaces simultaneously to at least two neighboring electrode spaces of the opposite polarity.

(DESIGN, VEHICLES, FUEL CELLS)

H78 34009 ENERGY SAVINGS THROUGH ON-SITE FUEL CELLS IN INDUSTRIAL APPLICATIONS

Voelker, G.E., (ERDA, Fuel Cell Branch, Washington, DC), Bolan, P., (United Technologies Corp., Power Systems Div., Farmington, CT), In Intersociety Energy Conversion Engineering Conference, 12th, Washington, DC, Aug 28 - Sept 2, 1977, Proceedings, American Nuclear Society, Inc., La Grange Park, IL, V 1:456-460, 1977, (A77-48701 23-44), A77-48752
Cogeneration with electric generating equipment located at or near the load rather than centrally stied can provide important means of conserving energy resources. The energy savings which could be achieved in certain industrial applications by use of on-site fuel cell powerplants have been examined. Twelve industrial processes were selected for study. A fuel cell system was specified for each of the twelve selected industrial processes and energy resource consumption was determined in each case. Eleven of the twelve applications used recovered heat as well as the electricity produced by the fuel cell. In six cases, process by-product fuel was used and in four processes direct current electricity was provided. When compared with

traditional energy resource consumption in each process, significant potential savings were found in all cases. In five of the processes studied, savings exceeded 20%. Overall, for the twelve processes investigated, extensive use of on-site fuel cell systems could result in resource savings of 190,000 barrels of oil (equivalent) per day.

(CONSERVATION, ELECTRIC POWER PLANTS)

H78 34010 ELECTROCHEMICAL ENGINEERING

(Pennsylvania Univ., Philadelphia, PA, Inst. for Direct Energy Conversion), Anodic Oxidation of Hydrogen in H_2SO_4 on Platinum Electrodes, Dec 1968, EDB-77:146044, N69-34813
Avail:NTIS
No abstract available

(ANALYTICAL SOLUTION, ELECTRIC CURRENTS)

H78 34101 NEW MATERIALS FOR FLUOROSULFONIC ACID ELECTROLYTE FUEL CELLS. INTERIM REPORT NUMBER 3, DEC 1975 - OCT 1976

Abens, S.G., Baker, B.S., George, M., Januszkiewicz, S., (Energy Research Corp., Bethel, CT), Feb 1977, AD-A-036988, EDB-77:132038
Avail:NTIS
Hydrogen-air fuel cells were evaluated with both TFMSA (trifluoromethane sulfonic acid) monohydrate and dilute TFMSA. Tolerance against flooding was increased by use of thick supported catalyst electrodes with the monohydrate. Fuel cells with 63 percent TFMSA were operated at room temperature for over 1,000 hours with no significant decay. The evaluation of supported platinum and tungsten carbide anode catalysts with dilute TFMSA was initiated. Silicon carbide was investigated as a matrix material with TFMSA.

(CATALYSTS, PERFORMANCE TESTING)

H78 34102 HEAT AND MASS TRANSFER ANALYSIS OF BACON-TYPE HYDROGEN-OXYGEN FUEL CELLS: THE VOLUME AVERAGE VELOCITY

Bayazitoglu, Y., (Univ. of Houston, Houston, TX), Smith, G.E., Int. J. Hydrogen Energy, V 2:139-153, N2, 1977, EDB-77:137383
A model is developed to study the transient electrolyte water evaporation and heat rejection in an operating fuel cell. The model applies to fuel cells which circulate reactant gas in excess of that consumed in the electrochemical reaction to remove the product water as well as heat. The model mass transfer equations are expressed in terms of volume average velocity. It has been shown that the mathematical representation of the volume average velocity model is attractive for computational purposes, since the volumetric disappearance of electrolyte volume for a fixed control volume in space would yield a change in concentration as would actually occur due to dilution. Because of the non-linearities associated with the developed model equations, the finite-difference technique is used to obtain solutions. The implicit finite-difference scheme was selected so as to avoid the stability criteria associated with the explicit form, which places an undesirable restriction on the size of the time increment that can be used. After its accuracy had been established, the method was used to study an operating bacon-type hydrogen-oxygen fuel cell.

(ELECTROLYSIS, MATHEMATICAL MODELS)

H78 34103 LOW TEMPERATURE HYDROGEN CELLS OF THE C.G.E.: EXISTING BATTERIES AND FUTURE PROSPECTS

DuBois, P., Edon, C., Compagnie Generale D'Electricite - CGE, 75, Paris, France, 1967, EDB-77:146034, N68-28729, In French and English
Avail:NTIS
No abstract available

(ELECTRODES, STORAGE)

H78 34104 PARAMETRIC MASS ANALYSIS AND COMPARISON OF TWO TYPES OF REACTANT COOLING-AND-STORAGE UNITS FOR A LUNAR-BASED HYDROGEN-OXYGEN REGENERATIVE FUEL-CELL SYSTEM

Hagedorn, N.H., (NASA, Lewis Research Center, Cleveland, OH), Feb 1968, EDB-77:146029, N68-16631
Avail:NTIS $3.00
No abstract available

(REFRIGERATORS)

H78 34105 DUAL MEMBRANE, HOLLOW FIBER FUEL CELL

Ingham, J.D., Lawson, D.D., (NASA, Pasadena, CA), Feb 3, 1977, EDB-77:146020, N77-19581,
Avail:NTIS

A gaseous fuel cell is described which includes a pair of electrodes formed by open ended, ion-exchange hollow fibers, each having a layer of metal catalyst deposited on the inner surface thereof and large surface area current collectors such as braided metal mesh in contact with the metal catalyst layer. A fuel cell results when the electrodes are immersed in electrolyte and electrically connected. As hydrogen and oxgyen flow through the bore of the fibers oxidation and reduction reactions develop an electrical potential. Because the hollow fiber configuration provides large electrode area per unit volume and intimate contact between fuel and oxidizer at the interface, and because of the low internal resistance of the electrolyte, high power densities can be obtained.

(DESIGN, ELECTRODES)

H78 34106 SEALING OF SILVER OXIDE-ZINC STORAGE CELLS. QUARTERLY REPORT, DECEMBER 23, 1967 - MARCH 23, 1968

(Douglas Aircraft Co., Inc., Newport Beach, CA, Astropower Lab.), Miniature Hybrid Fuel Cells for Pressure Control, Mar 23, 1968, EDB-77:145845, N68-27645
Avail:NTIS $3.00

No abstract available

(PERFORMANCE TESTING, GASES, BATTERIES)

H78 34201 DEVELOPMENT OF CATHODIC ELECTROCATALYSTS FOR USE IN LOW TEMPERATURE H_2O_2 FUEL CELLS WITH AN ALKALINE ELECTROLYTE. QUARTERLY REPORT, JANUARY 1 - MARCH 31, 1968

Giner, J., Parry, J., Swette, L., Cattabrega, R., (Tyco Labs., Inc., Waltham, MA), Mar 31, 1968, EDB-77:146033, N68-25891

No abstract available

(CATALYSTS, NICKEL CARBIDES)

H78 34202 TESTS AND EVALUATION OF FUEL CELL CATALYSTS. Final Report, MAY 3, 1967 - MAY 3, 1968

Flannery, R.J., Waters, R.F., (American Oil Co., Whiting Ind. Research and Development Dept., Whiting, IN), May 3, 1968, EDB-77:146031, N68-22236

No abstract available

(CHROMIUM COMPOUNDS, CORROSION RESISTANCE)

H73 34203 FEASIBILITY STUDY OF HIGH TEMPERATURE HYDROGEN-OXYGEN FUEL CELLS. Final Technical Report

Okrent, E.H., Lieberman, M., Heath, C.E., (ESSO Research and Engineering Co., Linden, NJ), Dec 1967, EDB-77:146024, N68-22889
Avail:NTIS $3.00

No abstract available

(EFFICIENCY)

H78 34204 DEVELOPMENT OF AN IMPROVED OXYGEN ELECTRODE FOR USE IN ALKALINE H_2O_2 FUEL CELLS. QUARTERLY REPORT, JANUARY 1 - MARCH 31, 1968

(Bureau of Mines, Pittsburgh, PA, Pittsburgh Coal Research Center), Mar 31, 1968, EDB-77:132041, N68-22706
Avail:NTIS $3.00

No abstract available

(CATALYSIS, CATHODES)

H78 34601 DEVELOPMENT OF AN IMPROVED OXYGEN ELECTRODE FOR USE IN ALKALINE H_2O_2 FUEL CELLS. QUARTERLY REPORT, APRIL 1 - JUNE 30, 1967

Akhtar, S., Grein, C.T., Diehl, R.C., Ryback, W.H., Bienstock, D., (Bureau of Mines, Pittsburgh, PA, Pittsburgh Coal Research Center), Transition Element Compounds and

Alloys, June 30, 1967, EDB-77:146027, N68-10251
Avail:NTIS $3.00
No abstract available

(COBALT ALLOYS, X-RAY DIFFRACTION)

H78 34602 PROPERTIES OF TUNGSTEN CARBIDE IN ELECTRODES FOR FUEL CELLS WITH ACID ELECTROLYTES

Binder, H., Kohling, A., Kuhn, W., Lindner, W., Sandstele, G., (Battelle Pacific Northwest Labs., Richland, WA), Energy Conversion, V 10:25-28, 1970, N77-76354, In German, English translation
No abstract available

(MATERIALS ANALYSIS)

H78 34603 SIMPLEX OPTIMIZATION OF CARBON ELECTRODES FOR THE HYDROGEN OXYGEN MEMBRANE FUEL CELL

Ceynowa, J., Wodzki, R., (Torun, Uniwersytet, Torun, Poland), Journal of Power Sources, V 1:323-331, Sept 1977, A77-50200
No abstract available

(PROGRAMMING,ION EXCHANGE)

H78 34604 THE HYDROGEN ELECTRODE IN MOLTEN CARBONATE

Vogel, W.M., Iacovangelo, C.D., (United Technologies Advanced Fuel Cell Research Laboratory, Middletown, CT), Electrochemical Society, Journal, V 124:1305-1309, Sept 1977, A77-46443
Open-circuit potentials are reported for the hydrogen (Au) electrode in molten carbonate at 650°C. The data, with few exceptions, agree with thermodynamic values calculated assuming simultaneous equilibrium of the shift and the methane reactions. The exceptions are those instances where methane has to be oxidized almost completely to reach equilibrium, and those where carbon can form during preheating of the gas.

(REACTION KINETICS, ALKALI METAL COMPOUNDS)

H78 35001 UTILIZATION OF OFF-PEAK POWER TO PRODUCE INDUSTRIAL HYDROGEN. Final Report

Biederman, N., Darrow, K., Jr., Konopka, A., (Institute of Gas Technology, Chicago, IL), 193 p., Aug 1975
The purpose of this study of the use of off-peak electricity to produce industrial hydrogen was to provide an analytical methodology for determining the economic and technical feasibility of using off-peak power to generate hydrogen that can then be sold to industry as a fuel or commodity. Such a scheme might represent an attractive use of off-peak power and could provide the first step toward building a hydrogen-energy system. This report comprises three major sections: (1) Market, which discusses the current and projected uses of hydrogen along with the likely market price situations. This section also presents briefly the market opportunities for oxygen. (2) Economics of Hydrogen Production, Storage, and Transportation, which provides the baseline data required for utilities to calculate a cost of electrolytic hydrogen for a specific situation and to compare that with the cost of alternative hydrogen production. This section likewise briefly addresses oxygen storage and transportation costs. (3) Methodology, which describes, via several specific examples, the methodology for calculating a hydrogen production cost and matching that with a likely market price. This section recognizes the uniqueness of individual utility situations and the necessity of providing the individual utility with the ability to perform its own analyses.

(INDUSTRIAL PLANTS, STORAGE)

IV. TRANSMISSION, DISTRIBUTION, AND STORAGE

H78 40001 PROCESS HEAT PLANT CONTAINING SOME REACTION CHAMBERS HEATED BY THE COOLING GAS OF HIGH TEMPERATURE REACTOR

Baumgaertner, H., German, FRG, Patent 2,455,507,A, May 26, 1976, EDB-77:131622, In German

The invention is concerned with the arrangement of the components of gas ducts of the parts within the prestressed concrete pressure vessel of the gas coolant-circuit (primary circuit) of a process heat plant for producing hydrogen which is heated by the gas of a high-temeprature nuclear reactor. All the components are removable separately and are well accessible. The heat is directly conducted to the reaction chambers without an intermediate circuit. The gas coolant circuit is divided into several identical loops installed in pods arranged symmetrically around the high-temperature reactor within the wall of the vessel. On backfeeding, the cool gas is conducted in a by-pass around the high-temperature components. An example explains in detail the proposed arrangement.

(PRODUCTION)

H78 40002 HYDROGEN TRANSMISSION - THE SIGNIFICANCE OF EFFICIENCY - IN COMPARISON WITH CONVENTIONAL ELECTRIC POWER SYSTEM

Falcone, C.A., (American Electric Power Service Corp., New York, NY), In Energy Development II, Institute of Electrical and Electronics Engineers, Inc., New York, p. 79-82, 1976, A78-10729 01-44, A78-10736

In a comparison of the efficiency of a conventional electric power system with a hydrogen-electric system, it is shown that energy conversion losses in the hydrogen system would result in much higher total energy consumption and would require greater power plant capacity for the same level of delivered energy. It is suggested that energy from a hydrogen-electric system would not only be more costly, but would result in a considerably greater environmental impact.

(COST EFFECTIVENESS, CONVERSION)

H78 40003 ASSESSMENT OF HYDROGEN AS A MEANS TO STORE SOLAR ENERGY

Ramakumar, R., (Oklahoma State Univ., Stillwater, OK), Sharing the Sun: Solar Technology in the Seventies, V 8, Boer, K.W., ed., American Section of the International Solar Energy Society, Cape Canaveral, FL, 1976, EDB-77:131084

A brief review and assessment of the use of hydrogen as a means to store solar energy is presented. Electrolytic and non-electrolytic methods proposed for hydrogen production from solar energy, hydrogen storage methods and utilization techniques are surveyed. Overall system concepts with several manifestations of solar energy as inputs are discussed along with their efficiencies and economic aspects.

(BIOSYNTHESIS, ECONOMICS, REVIEWS)

H78 40004 HYDROGEN STORAGE AND PRODUCTION IN UTILITY SYSTEMS. ANNUAL PROGRESS REPORT

Salzano, F.J., ed., (Brookhaven National Lab., Upton, NY), 105 p., N77-74344
Avail:NTIS

No abstract available

(BATTERIES, TEMPERATURE EFFECTS)

H78 40005 A NEW FAMILY OF HYDROGEN STORAGE ALLOYS BASED ON THE SYSTEM NICKEL-MISCHMETAL-CALCIUM

Sandrock, G.D., (International Nickel Co., Inc., Paul D. Merica Research Laboratory, Suffern, NY), In Intersociety Energy Conversion Engineering Conference, 12th, Washington, DC, Aug 28 - Sept 2, 1977, Proceedings, American Nuclear Society, Inc., La Grange Park, IL, V 1:951-958, 1977, research supported by the International Nickel Company, A77-48701 23-44, A77-48817

A family of low-cost intermetallic hydrogen storage compounds based on the formula $Ca_xM_{x-1}Ni5$ has been developed. M is the standard rare earth alloy mischmetal and x can be varied from 0 to 1. The basic properties are presented as a function of x, including pressure-temperature-composition relations, ease of activation, heats of reaction, relative materials cost, melting and other metallurgical considerations, and crystal structure correlations. The system offers several desirable properties including raw materials costs per unit of hydrogen storage capacity less than one-third that of present LANi5, room temperature plateau pressures ranging from 30 to 0.5 ATM, very low hystereis, and easy activation.

(COST REDUCTION, CLEAN ENERGY)

H78 40006 AN OFF-PEAK ENERGY STORAGE CONCEPT FOR ELECTRIC UTILITIES. I - ELECTRIC UTILITY REQUIREMENTS

Sulzberger, V.T., El-Badry, Y.Z., (Public Service Electric and Gas Co., Newark, NJ), Clifford, J.E., Brooman, E.W., (Battelle Columbus Laboratories, Columbus, OH), Applied Energy, V 3:167-188, July 1977, Research supported by the Battelle Columbus Laboratories, A77-49348

A water battery was evaluated in an analytical and conceptual design study as a load-leveling system for an electric utility. The water battery produced hydrogen and oxygen by electrolysis of water during periods when off-peak electrical power was available. During peak demand periods, the water battery, operating in the reverse mode, functioned as a fuel cell by producing electrical power through the recombination of the oxygen and hydrogen held in its storage vessels. Factors considered in the analysis include present and future energy requirements, current off-peak energy availability, typical sizing and placement of energy storage units, and the approximate break-even economics and potential advantages to the utility of a water battery energy storage system. In the cost effectiveness analysis, the water battery was compared with gas turbines and fuel cells.

(COST EFFECTIVENESS, ECONOMIC ANALYSIS)

H78 40007 ERDA'S CHEMICAL ENERGY STORAGE PROGRAM

Swisher, J.H., (ERDA, Div. of Energy Storage Systems, Washington, DC), Kelley, J.H., (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA), In Intersociety Energy Conversion Engineering Conference, 12th, Washington, DC, August 28 - Sept 2, 1977, Proceedings, American Nuclear Society, Inc., La Grange Park, IL, V 1:533-539, 1977, (A77-48701 23-44), A77-48763

The chemical energy storage program is described with emphasis on hydrogen storage. Storage techniques considered include pressurized hydrogen gas storage, cryogenic liquid hydrogen storage, storage in hydride compounds, and aromatic-alicyclic hydrogen storage. Some uses of energy storage are suggested. Applications of hydrogen energy systems include storage of hydrogen for utilities load leveling, industrial marketing of hydrogen both as a chemical and as a fuel, natural gas supplementation, vehicular applications, and direct substitution for natural gas.

(CRYOGENIC FLUID, HYDRIDES, PRESSURE VESSELS)

H78 40101 CO STEAM - THE NEWEST COAL LIQUEFACTION PROCESS

Appell, H.R., (ERDA, Pittsburgh Energy Res. Cent, PA), Monogr. on Alternate Fuel Resour. Based on Pap. Presented at the Symp. on Alternate Fuel Resour., Santa Maria, CA, Mar 25-27, 1976, Publ by West Period Company, North Hollywood, CA, AIAA, V 20:74-79, 1976

COSteam is a process for the conversion of lignite and some bituminous coals to a low-sulfur, low-ash, industrial fuel oil using synthesis gas (carbon monoxide plus hydrogen) and water in place of hydrogen. The mineral components naturally present in the coals used in this process provide enough catalytic activity so that the presence of added catalysts is not necessary. Conversions of coal to fuel oil plus water and gas average near 90 percent at temperatures of 425° to $450^{\circ}C$ and can pressure 3,000 to 4,000 PSIG. In the case of lignite, the conversions with synthesis gas are actually higher than those obtained with hydrogen at the same conditions in the absence of added catalysts. In the case of bituminous coals, the use of synthesis gas does not result in higher yields, compared to hydrogen, but results in lower processing costs.

(LIGNITE, ECONOMICS, SYNTHESIS GAS)

H78 40102 COAL LIQUEFACTION SUPPORT STUDIES.
TASK 1: HEAT OF REACTION OF HYDROGEN WITH COAL SLURRIES.
TASK 2: HEAT TRANSFER COEFFICIENT
QUARTERLY REPORT, OCT - DEC 1976

Fischer, J., Lo, R., Mulcahey, T., Fredrickson, D., Cannon, T., Jonke, A., (Argonne National Lab, IL), 16 p., N77-85045
Avail:NTIS

No abstract available

(SYNTHETIC FUELS)

H78 40103 LIQUEFACTION SUPPORT STUDIES.
TASK 1: HEAT OF REACTION OF HYDROGEN WITH COAL SLURRIES.
TASK 2: HEAT TRANSFER COEFFICIENT
QUARTERLY REPORT, JANUARY - MARCH 1977

Fischer, J., Young, J., Lo, R., Mulcahey, T., Fredrickson, D., Cannon, T., Jonke, A., (Argonne National Lab., IL), 2 refs, 1977, ANL-77-38, EDB-77:136413
Avail:NTIS

A development program is being carried out to obtain information applicable to the synthoil process for converting coal to liquid fuel of low sulfur content. This report presents information on: (1) a calorimeter to measure heat of reaction of hydrogen with coal slurries and (2) the construction status and a test program for the apparatus for measuring heat transfer coefficients of synthoil feed and effluents.

(MOLYBDENUM SULFIDES, PERFORMANCE TESTING)

H78 40104 STUDIES OF HYDROGEN LIQUEFIER EFFICIENCY AND THE RECOVERY OF THE LIQUEFACTION ENERGY

Voth, R.O., Parrish, W.R., (National Bureau of Standards, Cryogenics Div., Boulder, CO), 63 p., Aug 1977, (Report No. NBSIR-77-862), Project No. NBS-2750153

Liquid hydrogen is a potential synthetic fuel. It is nonfossil, its production and storage technology is well developed, and it is inherently nonpolluting. However, the economics of liquefying hydrogen are costly both in the energy required to produce the liquid and in the capital costs of the liquefier. These costs could be reduced by increasing the liquefier efficiency and/or by recovering a portion of the liquefaction energy at the use site. This paper provides the maximum hydrogen liquefier efficiency based on the efficiency of available components and the fraction of original liquefaction energy that can be recovered at the use site. Since the inefficient compressors and expanders are the major cause of liquefier inefficiency, no increase in liquefier efficiency above the current 30 to 35 percent is probable without a corresponding increase in compressor and expander efficiency - a difficult task since both the compressors and expanders have a long and stable history of development. However, roughly one-third to one-half of the actual energy required to liquefy hydrogen can be recovered at the use site and this represents a cost credit for liquid hydrogen.

(COST ANALYSIS, EVALUATION, EFFICIENCY)

H78 40301 THIN FILM ATOMIC HYDROGEN DETECTORS. Final Report

Gruber, C.L., (South Dakota School of Mines and Technology, Rapid City, SD, Department of Electrical Engineering), NASA-CR-152605, NAS5-23470, 33 p., N77-33482
Avail:NTIS

Thin film and bead thermistor atomic surface recombination hydrogen detectors were investigated both experimentally and theoretically. Devices were constructed on a thin mylar film substrate. Using suitable wheatstone bridge techniques sensitivities of 80 microvolts/2 x 10^{13} atoms/sec are attainable with response to time constants on the order of 5 seconds.

(MEASURING INSTRUMENTS, THERMAL ENERGY)

H78 40401 INVESTIGATION OF CRYOGENIC CYCLES WITH WET VAPOR EXPANSION MACHINES

Ardashev, V.I., Mikulin, E.I., Plachendovskii, D.I., Zholsharev, A., (Moscow Higher Tech. Sch. N. E. Bauman, USSR), Izv Vyssh Uchebn Zaved Mashinostr, p. 87-92, N3, 1977, In Russian

Analysis is given of cycles of cryogenic air, hydrogen, and helium liquefying installations with wet vapor expansion machines instead of a throttle at the lower stage of cooling. They are compared with similar cycles that include a throttle, other conditions being equal. The comparison concerns energy consumption per unit of the cryogenic product and the conventional specific heat transferring surface of liquefier heat exchangers.

(HEAT EXCHANGERS)

H78 40601 ALTERNATIVE FORMS OF ENERGY TRANSMISSION FROM OTEC PLANTS

Konopka, A., Biederman, N., Talib, A., Yudow, B., (Institute of Gas Technology, Chicago. IL), 1977, CONF-770331-5, EDB-77:124816
Avail:NTIS

The transmission of OTEC-derived chemical and electrical energy is compared. The chemical energy-carriers considered are the following: gaseous and liquid hydrogen, liuqid ammonia, methanol, gasoline, hydrazine hydrate, anhydrous hydrazine, unsymmetrical dimethylhydrazine (UDMH), 1, 7-octadeyne, and tetrahydrodicyclopentadiene. The assessment assumes that each of the above energy carriers were transported by barge and/ or pipeline. The delivered costs were then compared with transmission of electricity by submarine cables. Because chemical and electrical energy are not equivalent, however, their comparison can only be done after the outputs are converted to a common form. Thus, in addition to presenting the delivered cost and overall energy efficiency of the chemical energy-carriers, we have provided a discussion of the equipment, costs, and efficiencies of converting the hydrogen and ammonia delivered into electricity, and the electricity delivered into hydrogen and ammonia. A concise technical assessment and economic analysis of components associated with the conversion, storage, transportation, and shore-based receiving facilities for the conversion of OTEC mechanical energy to chemical energy is provided and compared to the conversion and transmission of electrical power. Results concerning the hydrogen and ammonia analysis were determined as part of the OTEC program at IGT from May 1975 through May 1976 under contract No. NSF-C1008 (AER-75-00033) with the National Science Foundation and ERDA. Information concerning carbonaceous fuels and high-energy fuels production was developed as part of the current IGT OTEC program under contract No. E(49-18)-2426 with ERDA.

(ECONOMICS, EFFICIENCY, FEASIBILITY STUDIES)

H78 40602 PRODUCTION OF HIGH-BTU OIL GAS IN A CYCLIC-REGENERATIVE PILOT UNIT WITH HYDROGEN AS CARRIER GAS

Reid, J.M., Bair, W.G., Linden, H.R., (Institute of Gas Technology, Chicago, IL), J. Inst. Fuel, p. 325-334, July 1958, EDB-77:131047

The results of a study of the production of high-BTU oil gas by cyclic thermal cracking of petroleum oils are presented. Experimental data were obtained using a four-shell, cyclic-regenerative pilot unit of improved design and with a nominal make (process) oil capacity of 50 gallons per hour. The improved design features include the use of clean regenerators instead of the conventional superheaters, elimination of hot valves and substitution of a dual, closed circulation product quench system for the conventional water-sealed wash box. These features reduced the deposition of coke and pitch, problems of handling by-products and smoke formation. In addition, the high-BTU oil gas contained less inerts than that produced in conventional sets. Complete operating data were obtained at make (gasification) pressures up to 50 PSIG, and at carrier gas hydrogen rates of up to 65 SCF per gallon of make oil. Results indicate that the use of process hydrogen permits the production, from all types of oil, of gases of 1,000 BTU per standard cubic foot, and of 0.6 to 0.7 specific gravity with combustion characteristics approaching those of natural gas. At make pressures up to 10 PSIG, set capacities were increased by 20 percent for low-grade residual oils, and by more than 40 percent for premium oils. At 30 to 50 PSIG, maximum make pressure, set capacities were not significantly increased by the use of hydrogen/with residual oils, substantial reductions in conversion to gas and excessive coke laydown were observed. However, after light oil removal, the make gases could be completely substituted for natural gas on critical appliance burners over most of the usual range of adjustments.

(GASIFICATION, PRODUCTION, SNG PROCESSES)

H78 43001 HYDROGEN STORAGE PREPARATION OF THE HYDRIDE PHASE $Ti_2Fe_xM_{1-x}H_4$. ANNUAL SUMMARY REPORT, JUNE 1, 1975 - MAY 31, 1976

Adkins, C.M., III, (Virginia Univ., Charlottesville, VA), 135 p., Mar 1977

The following conclusions were reached. A phase forms from fine grained alloys in the vicinity of the stoichiometry. Ti_2Fe, which indexes as cubic with an 11.30 +- 0.01 Angstrom cell edge. A phase can be formed close to the Ti_2Fe stoichiometry by addition of a third element, and that phase will react with hydrogen. The Engel-Brewer correlation successfully predicted the compositon, Ti_2X-II-4, which formed in the $E9_3$ structure. The application of the Engel-Brewer correlation to the FeTi model has suggested that the reaction of hydrogen with FeTi is governed by the effects of the interaction of hydrogen with the electronic structure of the alloy.

(COBALT ALLOYS, TITANIUM ALLOYS, PHASE STUDIES)

H78 43002 METAL HYDRIDES AS FUEL TANKS FOR VEHICLES

Mintz, M.H., Hadari, Z., (Nucl. Res. Cent., Negev., Be'er Sheva, Israel), Isr. J. Technol., V 14:231-234, N4-5, 18 refs, 1976, EDB-77:144535

Comparison is made with three other alternatives for hydrogen storage systems, from which metal hydrides seem to exhibit the most convenient properties. The various factors involved in the hydride selection are analzyed. A minimum hydrogen content (WT percent) of 6-7 percent is shown to be essential in choosing the appropriate hydride, which excludes most metal-hydrogen systems. Considering some other factors, it is consluded that the only suitable systems are certain magnesium-alloy hydrides. Recent research done in this field is reviewed.

(AUTOMOBILES, COMPARATIVE EVALUATIONS)

H78 43003 METAL HYDRIDES OF IMPROVED HEAT TRANSFER CHARACTERISTICS

Ron, M., (Dept. of Materials and Metall. Engng., Stevens Inst. of Technol., Hoboken, NJ), Eleventh Intersociety Energy Conversion Engineering Conference, State Line, NV, Sept

12-27, 1976, American Inst Chem Engrs, New York, NY, p. 954-960, 16 refs, 1976
The poor heat transfer response of a bed of powdered metal hydride is a considerable constraint on the design of a hydrogen storage device. Metal hydrides consolidated in a highly porous metallic matrix are shown to have improved heat transfer features. A preliminary evaluation of thermal conductivity and heat transfer characteristics is given. The beneficial effects of these materials on the heat transfer of hydrogen storage devices are discussed for vehicle, secondary battery and hydrogen compressor applications.

(HYDROGEN STORAGE DEVICE)

H78 43004 PROBLEM OF METALLIC HYDROGEN

Yakovlev, E.N., (Addis Translations International, Portolà Valley, CA), (California Univ., Livermore, Lawrence Livermore Lab, Livermore, CA), p. 66-69, N4, 1976, N77-80458, In Russian, English translation
Avail:NTIS
No abstract available

(ELECTRON TRANSITIONS, STATIC PRESSURE)

V. SAFETY

H78 50001 OVERVIEW OF SURFACE RELATED PROBLEMS IN THE NUCLEAR ENERGY FIELD

Colmenares, C.A., (California Univ., Livermore, Lawrence Livermore Lab, CA), p. 65, May 25, 1977, (Contract No. W-7405-ENG-48)

An extended set of viewgraphs used in a talk on surface-related problems in the nuclear energy field is assembled in this report. Materials problems in the areas of fission reactors, hydrogen storage, catalysis, nuclear weapons, bullets, and nuclear waste disposal and fuel reprocessing are included. The viewgraphs are reasonably self-contained; there is no text.

(HYDROGEN STORAGE)

H78 50002 CRYOGENICS SAFETY

Reider, R., (Los Alamos Scientific Lab., NM), National Conference on Campus Safety on the Univ. of Hawaii Campus, Honolulu, Hawaii, 18 p., June 9, 1977, (Contract No. W-7405-ENG-36)

The safety hazards associated with handling cryogenic fluids are discussed in detail. These hazards include pressure buildup when a cryogenic fluid is heated and becomes a gas, potential damage to body tissues due to surface contact, toxid risk from breathing air altered by cryogenic fluids, dangers of air solidification, and hazards of combustible cryogens such as liquified oxygen, hydrogen, or natural gas or of combustible mixtures. Safe operating procedures and emergency planning are described.

(HAZARDS, LIQUEFIED NATURAL GAS)

H78 52001 POSITRON STUDIES OF FATIGUE, HYDROGEN EMBRITTLEMENT AND RADIATION DAMAGE IN METALS

Byrne, J.G., Alexopoulos, P., Alex, F., Hadnagy, T.D., Waki, R., (Utah Univ., Salt Lake City, UT), International Conference on Positron Annihilation, Helsingor, Denmark, 7 p., Aug 23, 1976, (Contract No. E(11-1)-2128

Polycrystalline copper was followed in both cyclic softening and hardening with positron lifetime and x-ray particle size measurements. As initially hard copper is fatigue cycled, the mean positron lifetime decreases while the x-ray particle size increases. Similar correlation exists during fatigue hardening of initially soft copper, i.e., the mean positron lifetime increases while the x-ray particle size decreases. The trends indicate a positron response to decreasing dislocation density during fatigue softening and the converse during fatigue hardening. Hydrogen embirttlement effects in AISI 4340 steel and nickel were followed with mean positron lifetime. It appears that the effects are caused by mutual interaction of dislocations, protons, and positrons. In single crystal copper irradiated at 80^{O}K with 4.5-MeV electrons, about 8 percent of the defects produced appear to be divancies and the balance simple Frenkel defects. Stage III annealing data suggest that both mono and divancies are removed and that s stable multivacancy unit exists at temperatures above the stage III region. These entities could could serve as nucleation centers for voids.

(STEELS, ANNEALING, STRAIN HARDENING)

H78 52002 APPLICATION OF NUCLEAR REACTIONS FOR QUANTITATIVE HYDROGEN ANALYSIS IN A VARIETY OF DIFFERENT MATERAILS PROBLEMS

Clark, G.J., White, C.W., Allred, D.D., Appleton, B.R., Koch, F.B., (Oak Ridge National Lab, TN), International Conference on Ion Beam Analysis, Washington, DC, 30 p., June 27, 1977, (Contract No. W-7405-ENG-26)

The application of nuclear reaction techniques to hydrogen analysis problems in metallurgical, mineralogical and semi-conductor areas are described. Hydrogen analyses and profiles obtained with both the reactions are presented. The advantages and disadvantages of the two techniques are discussed. Both crystalline and amorphous materials are examined. Particular emphasis will be given to interpretative problems associated with analyzing the data. Various corrections to the data will be discussed, including off-resonance cross-section corrections and lower energy resonance corrections. The hydrogen content of electrodeposited hard gold films has been determined as a function of plating conditions. Hydrogen contents as high as 9 atom percent have been measured. The hydrogen profile of natural and synthetic SiO_2 samples was determined. Hydrogen was found to be quite stable in amorphous silica samples but highly mobile in crystalline quartz samples under the analysis conditions. A hydrogen depth profile for a film of glow and discharge deposited amorphous silicon (approximately 4500 A thick) has been obtained and will be compared with a profile measured by secondary ion mass spectrometry (SIMS) on the same sample.

(TECHNIQUES, ELECTRODEPOSIT)

H78 52003 STRESS CORROSION CRACKING OF STAINLESS STEELS. CHOICE OF A STEEL AND A TEST. CASE OF A MAGNESIUM CHLORIDE SOLUTION. LIMITS OF VALIDITY

Desestret, A., (Cent. de Rech. d'Unieux, Ste Creusot-Loire, France), Mater Tech, V 65:259-272, N5, 7 refs, May 1977, In French

Reviewed are three main hypotheses which attempt to take into account and describe in detail the phenomena of stress corrosion cracking in austenitic stainless steels - namely, a hypothesis in which cracking is due to rupture of the passive layer by mechanical stresses, a hypothesis involving a mechanism of hydrogen embrittlement of the metal, and a hypothesis in which cracking is attributed to a reduction of surface energy caused by the absorption of certain ions with unusual properties. In the case of martensite and austenitic stainless steels two modes of stress corrosion cracking are distinguished - namely, cracking by hydrogen embrittlement, observed mainly on steels of martensitic structure immersed in an acidic or chlorinated medium; and so-called "anodic" cracking, which occurs on austenitic stainless steels immersed in chlorinated or basic media. Finally, in the case of ferrites and austeno-ferritic stainless steels the results of tests in which the metals were immersed in concentrated solutions of boiling magnesium chloride are presented and evaluated.

(EMBRITTLEMENT)

H78 52004 HYDROGEN EMBIRTTLEMENT OF METALS, VOLUME 2, 1975-1976. CITATIONS FROM THE NTIS DATA BASE

Smith, M.F., ed., NTISearch, NTIS/PS-77/0004/OENS, Search period covered 1975-1976, Publ by Natl. Tech. Inf. Serv., Springfield, VA, 106 p., Jan 1977
Avail:NTIS or Eng Index, New York

Results of studies on hydrogen embirttlement relative to mechanical properties, irradiation, crystal structure and corrosion are cited. This compilation also covers testing, hydrogen analysis and diffusion, welding, electroplating, fabrication and processing with respect to the ductile brittle transition in metals. Reports on nuclear rector materials, hydrogen storage equipment and energy related systems are included. This updated bibliography contains 101 abstracts, 75 of which are new entries to the previous edition covering the period 1975 through 1976.

(METALLURGY, ELECTROPLATING)

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MICAL-REACTION-KINETICS#	MULTISTAGE, DECOMPOSITION, CHE	023402
S, SAFETY, HAZARDS, LIQUEFIED	NATURAL GAS# CRYOGENIC	050002
POTENTIAL, PRODUCTION, MAGMA,	NATURAL OCCURRENCE, ROCK-FLUID	023001
, USES# HYDROGEN,	NETHERLANDS, SAFETY, TRANSPORT	010013
ELECTROCATALYSTS, CATALYSTS,	NICKEL CARBIDES, FUEL-CELLS#	034201
ECRAFT-ENERGY#	NICKEL-HYDROGEN, BATTERY, SPAC	034002
RIZATION, ANALYSIS, HYDROGEN,	NITROGEN# /ID, WASTE, CHARACTE	023804
THERMAL# RESEARCH,	NONFOSSIL, ELECTROLYSIS, OCEAN	010014
L, PRODUCTION, MAGMA, NATURAL	OCCURRENCE, ROCK-FLUID INTERAC	023001
RCH, NONFOSSIL, ELECTROLYSIS,	OCEAN THERMAL# RESEA	010014
TORAGE# UTILIZATION,	OFF-PEAK, INDUSTRIAL PLANTS, S	035001
COST-EFFECTIVENESS, ECONOMIC/	OFF-PEAK, STORAGE, UTILITIES,	040006
ON, ECONOMICS, BIOMASS, COST,	OIL SHALES# TRANSPORTATI	010001
FACTURE# DEVELOPMENTS,	OIL, SHALE, LIQUID FUELS, MANU	022004
RAMMING, ION EXCHANGE#	OPTIMIZATION, ELECTRODES, PROG	034603
OWER-SUPPLIES, SOLAR CELLS#	OPTIMUM, STORAGE, SPACECRAFT-P	030002
YDROGEN STORAGE#	OVERVIEW, SURFACE, PROBLEMS, H	050001
DECOMPOSITION, INCINERATORS,	OXIDATION# /AL, DETERMINATION,	023806
CE-TESTING, GASES, BA/ SILVER	OXIDE-ZINC, STORAGE, PERFORMAN	034106
UIPMENT ELECTRICAL,/ HYDROGEN	OXYGEN FUEL-CELLS, LIGHTING EQ	030003
SILVER OXIDE-ZINC, STORAGE,	PERFORMANCE-TESTING, GASES, BA	034106
SUMPTION, GASOLINE, MIXTURES,	PERFORMANCE-TESTING, FUEL-CONS	033001
FACTION, COAL, HEAT-TRANSFER,	PERFORMANCE-TESTING, MOLYBDENU	040103
GRAM, FABRICATION, MATERIALS,	PERFORMANCE-TESTING# /ELL, PRO	035001
S, FLUOROSULFONIC, CATALYSTS,	PERFORMANCE-TESTING# /UEL-CELL	034101
SYSTEMS, DESIGN, ENGINEERING,	PERFORMANCE-TESTING# /OGENIC,	032005
GINES, MIXTURES, COMBUSTION-/	PERFORMANCE, RECIPROCATING, EN	033002
BALT-ALLOYS, TITANIUM-ALLOYS,	PHASE STUDIES# /E, HYDRIDE, CO	043001
OGRAPHY, MIXTURES#	PHASE, EQUILIBRIA, GAS-CHROMAT	022005
ON EFFICIENCY, SUNLI/ YIELDS,	PHOTOCHEMICAL, ENERGY-CONVERSI	023002
WDER-MANUFG., STORAGE#	PHOTOLYSIS, PHOTOREDUCTION, PO	023603
MATERIALS, WATER,	PHOTOLYSIS, SEMICONDUCTOR#	023602
, STORAGE# PHOTOLYSIS,	PHOTOREDUCTION, POWDER-MANUFG,	023603
IZATION, OFF-PEAK, INDUSTRIAL	PLANTS, STORAGE# UTIL	035001
ON, HYDRODYNAMICS, INDUSTRIAL	PLANTS# COAL-CONVERSI	022013
SSESSMENT, FUELS, PRODUCTION,	POLICY# PRELIMINARY, A	010004
CHMENT, EMISSION, COMBUSTION,	POLLUTION-CONTROL, FUEL-FEEDIN	031002
IR RATIO# COMBUSTION,	POLLUTION, CARBURETORS, FUEL-A	033004
, COMPARISON, FUEL-TANKS, AIR	POLLUTION# STORAGE, VEHICLES	032009
CONOMY# VEHICLE, EVALUATION,	POSTAL, DIESEL-ENGINES, FUEL-E	032003
ONOMY#	POTENTIAL, CARRIER, REVIEW, EC	010008
NATURAL OCCURRENCE, ROCK-FLU/	POTENTIAL, PRODUCTION, MAGMA,	023001
PHOTOLYSIS, PHOTOREDUCTION,	POWDER-MANUFG., STORAGE#	023603
MENTATION, COAL-GASIFICATION,	POWER-DEMAND# /T, COSTS, IMPLE	034003
, PRODUCTION, POLICY#	PRELIMINARY, ASSESSMENT, FUELS	010004
E, CRYOGENIC FLUID, HYDRIDES,	PRESSURE VESSELS# /CAL, STORAG	040007

ELECTRON TRANSITIONS, STATIC	PRESSURE# METALLIC, HYDROGEN,	043005
OVERVIEW, SURFACE,	PROBLEMS, HYDROGEN STORAGE#	050001
AGRICULTURE# LABORATORY,	PROCEDURES, CHEMICAL-ANALYSIS,	023802
MODEL, GASIFICATION,	PROCESS-ENGINEERING#	022011
IS# SEPARATION, HYDROGEN,	PROCESS-HEAT-REACTORS, PYROLYS	023401
GASIFICATION, PRODUCTION, SNG	PROCESSES# /IGH-BTU, CARRIER,	040602
COAL-GASIFICATION# FUELS,	PROCESSING, COAL-LIQUEFACTION,	010010
ANY, METHANE#	PRODUCITON, HYDROCARBONS, GERM	022007
TURE-EFFECTS# STORAGE,	PRODUCTION, BATTERIES, TEMPERA	040004
GASIFICATION, PRODUCTION, S/	PRODUCTION, HIGH-BTU, CARRIER,	040602
-REACTIONS, THERMOCHEMICAL-P/	PRODUCTION, HYDROGEN, CHEMICAL	021005
URRENCE, ROCK-FLU/ POTENTIAL,	PRODUCTION, MAGMA, NATURAL OCC	023001
ELIMINARY, ASSESSMENT, FUELS,	PRODUCTION, POLICY# PR	010004
D, FUEL, AUTOMOTIVE, HYDROGEN	PRODUCTION, ROAD TESTS# /FORME	032007
H-BTU, CARRIER, GASIFICATION,	PRODUCTION, SNG PROCESSES# /IG	040602
LAR ENERGY, KINETICS, CYCLES/	PRODUCTION, THERMOCHEMICAL, SO	021501
REACTOR, CHAMBERS, COOLING,	PRODUCTION#	040001
MOCHEMICAL, COST, EFFICIENCY,	PRODUCTION# /MENTS, ZNSE, THER	021004
S, PERFORMANCE-TE/ FUEL-CELL,	PROGRAM, FABRICATION, MATERIAL	034001
OPTIMIZATION, ELECTRODES,	PROGRAMMING, ION EXCHANGE#	034603
MATHEMATICAL MODELS, RESEARCH	PROGRAMS# ELECTROCHEMICAL,	020004
EFIED GASES, PYROTECHNICS, T/	PROGRESS, ENGINE, ARIANE, LIQU	030005
ALS ANALYSIS#	PROPERTIES, ELECTRODES, MATERI	034602
GENESIS,	PROPULSION, FUELS, SPACECRAFT#	030006
ROGEN, PROCESS-HEAT-REACTORS,	PYROLYSIS# SEPARATION, HYD	023401
INE, ARIANE, LIQUEFIED GASES,	PYROTECHNICS, TEST FACILITIES#	030005
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E CYLINDER, MIXTURE, FUEL-AIR	RATIO, SPARK-IGNITION# SINGL	033003
LUTION, CARBURETORS, FUEL-AIR	RATIO# COMBUSTION, POL	033004
L-COMP/ ELECTRODE, CARBONATE,	REACTION-KINETICS, ALKALI-META	034604
E, ENERGY, CHEMICAL-REACTION,	REACTION-KINETICS# STORAG	023003
YDROGEN, GASIFICATION, STEAM,	REACTION-KINETICS# H	022010
CATION, INJECTION, EXOTHERMIC	REACTIONS, METHANE# GASIFI	022009
CDUCTION#	REACTOR, CHAMBERS, COOLING, PR	040001
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ES, COMBUSTION-/ PERFORMANCE,	RECIPROCATING, ENGINES, MIXTUR	033002
MPOSITION, WATER, ULTRAVIOLET	REDIATION# CATALYSIS, DECO	023601
DROGEN PRODUCTION, ROAD TEST/	REFORMED, FUEL, AUTOMOTIVE, HY	032007
MASS, ANALYSIS, LUNAR-BASED,	REFRIGERATORS#	034104
L-GASIFICATION, EVALUATIONS#	REFUELING, TRANSIT, BUSES, COA	032001
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SERVICE LIFE# FUEL-CELL	RELIABILITY, FLOW REGULATORS,	034005
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SOURCES, MANAGEMENT#	RESEARCH, DEVELOPMENT, ENERGY-	010003
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SIS, OCEAN THERMAL#	RESEARCH, NONFOSSIL, ELECTROLY	010014
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HYDROGEN, ECONOMY, CHEMIST,	REVIEW, ENERGY#	010009
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ONS, FUSION, HYBRID REACTORS,	REVIEWS, SAFETY# APPLICATI	020501
LAR, BIOSYNTHESIS, ECONOMICS,	REVIEWS# /SSESSMENT, STORE, SC	040003
OMOTIVE, HYDROGEN PRODUCTION,	ROAD TESTS# /FORMED, FUEL, AUT	032007
N, MAGMA, NATURAL OCCURRENCE,	ROCK-FLUID INTERACTIONNS# /TIO	023001
TAL, SYSTEMS, HYDROGEN FUELS,	ROCKET ENGINES# EARTH-ORBI	030004
URAL GAS# CRYOGENICS,	SAFETY, HAZARDS, LIQUEFIED NAT	050002
HYDROGEN, NETHERLANDS,	SAFETY, TRANSPORT, USES#	010013
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ONS, CONSERVATION, ELECTRIC-/	SAVINGS, FUEL-CELLS, APPLICATI	034009
HYDROGEN, ECONOMY,	SECONDARY ENERGY-CARRIER#	010005
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HEAT-REACTORS, PYROLYSIS#	SEPARATION, HYDROGEN, PROCESS-	023401
RELIABILITY, FLOW REGULATORS,	SERVICE LIFE# FUEL-CELL	034005
RE# DEVELOPMENTS, OIL,	SHALE, LIQUID FUELS, MANUFACTU	022004
ECONOMICS, BIOMASS, COST, OIL	SHALES# TRANSPORTATION,	010001
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RFORMANCE-TESTING, GASES, BA/	SILVER OXIDE-ZINC, STORAGE, PE	034106
-AIR RATIO, SPARK-IGNITION#	SINGLE CYLINDER, MIXTURE, FUEL	033003
ER, GASIFICATION, PRODUCTION,	SNG PROCESSES# /IGH-BTU, CARRI	040602
E, SPACECRAFT-POWER-SUPPLIES,	SOLAR CELLS# OPTIMUM, STORAG	030002
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CTROLYSIS, / HYDROGEN, STORE,	SOLAR, COST-EFFECTIVENESS, ELE	010011
SIGN, VEHICLES, FUEL-CELLS#	SOLID-ELECTROLYTE, STORAGE, DE	034008
ING APPARATUS, WASTE DISPOSAL	SOLID-WASTE# /TERMINATION, DRY	023805
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, ANALYSIS, HYDROGE/ METHODS,	SOLID, WASTE, CHARACTERIZATION	023804
ICAL, ENGINEERING, ANALYTICAL	SOLUTION, ELECTRIC-CURRENTS# /	034010
E, INDUSTRIES, ME/ MATERIALS,	SPACE, MANUFACTURING, ABUNDANC	030001
NICKEL-HYDROGEN, BATTERY,	SPACECRAFT-ENERGY#	034002
AR CELLS# OPTIMUM, STORAGE,	SPACECRAFT-POWER-SUPPLIES, SOL	030002
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, INDUCTION, MIXING, EXHAUST,	SPARK-IGNITION# WATER	033006
DER, MIXTURE, FUEL-AIR RATIO,	SPARK-IGNITION# SINGLE CYLIN	033003
DROGEN, ELECTRON TRANSITIONS,	STATIC PRESSURE# METALLIC, HY	043004
ECONOMICS, SYNTHESIS-GAS# CO	STEAM, LIQUEFACTION, LIGNITE,	040101
HYDROGEN, GASIFICATION,	STEAM, REACTION-KINETICS#	022010
UE, EMBRITTLEMENT, RADIATION,	STEELS, ANNEALING, STRAIN HARD	052001
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N, CLEAN ENERGY#	STORAGE, ALLOYS, COST-REDUCTIO	040005
IDES, PRESSURE VEL/ CHEMICAL,	STORAGE, CRYOGENIC FLUID, HYDR	040007
L-CELLS# SOLID-ELECTROLYTE,	STORAGE, DESIGN, VEHICLES, FUE	034008
TION, REACTION-KINETICS#	STORAGE, ENERGY, CHEMICAL-REAC	023003
S, TITANIUM-ALLOYS, PHASE ST/	STORAGE, HYDRIDE, COBALT-ALLOY	043001
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, TEMPERATURE-EFFECTS#	STORAGE, PRODUCTION, BATTERIES	040004
LIES, SOLAR CELLS# OPTIMUM,	STORAGE, SPACECRAFT-POWER-SUPP	030002
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G INSTRUMENTS, THERMAL-ENERG/	THIN FILM, DETECTORS, MEASURIN	040301
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ION, EVALUATIONS# REFUELING,	TRANSIT, BUSES, COAL-GASIFICAT	032001
ST, IRON HYDRIDES, REFUELING,	TRANSIT# BUSES, CO	032010
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-EFFECTIVENESS, CONVERSION#	TRANSMISSION, EFFICIENCY, COST	040002
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SYTHETIC FUELS SUB/ SUBSONIC,	TRANSPORT, ENERGY-TECHNOLOGY,	031003
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, LIQUID HYDROGEN, SUPERSONIC	TRANSPORTS# ALTERNATE, FUELS	031001
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S, LIQUID HYDROGEN, MILITARY,	UTILITY# JET ENGINE FUEL	031004
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IAL PLANTS, STORAGE#	UTILIZATION, OFF-PEAK, INDUSTR	035001
IESEL-ENGINES, FUEL-ECONOMY#	VEHICLE, EVALUATION, POSTAL, D	032008
TIVE EVALUATIONS# HYDRIDES,	VEHICLES, AUTOMOBILES, COMPARA	043002
KS, AIR POLLUTION# STORAGE,	VEHICLES, COMPARISON, FUEL-TAN	032009
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HNOLOGY# SYNGAS,	WASTE, UTILIZATION, ENERGY-TEC	023801
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UST, SPARK-IGNITION#	WATER, INDUCTION, MIXING, EXHA	033006
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